A SHORT TREATISE
of Magneticall Bodies and Motions.

By
Marke Ridley Dr in phiſicke
and Philoſophie.
Lately
Phyſition to the Emperour
of Ruſsia, and one of ye eight
principals or Elects of the
Colledge of Phyſitions
in London.

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A Preface Magneticall.

P*urpoſing to deliuer a briefe and eaſie doctrine as concerning this new Art of* Magneticall Bodies and Motions: *I thought good here to free the ſame from the luſtre and gloſſe of diſputable points and other conceits, onely purpoſing to handle nothing in the ſame but the plaine matter and demonſtrations* Magneticall *themſelues, thinking it more fitting to place theſe flowers in the Preface, if any delight rather in them, then in the matter it ſelfe, to the end they may in ſome ſort be prouided of both. As concerning the firſt finding out of the* Magnet-ſtone, *whereof I am to treate,* Plinie *and* Nicander *haue fained that a certaine Heardman being in the fields, hauing his ſhoes ſhod with iron, and his ſtaffe armed with an iron pike, and reſting himſelfe vpon a quantity of this ſtone, could not eaſily remoue his feete, or lift vp his ſtaffe, whereupon he perceiued the attractiue vertue of this ſtone, that it did attract and hold iron. Other thinke that the pioners and diggers of mettals, by their diligence and obſeruances firſt found out the* Load-ſtone, *and his vertue of attracting iron, by which property it was well knowne to the auntient* Egyptians *and* Græcians *in times paſt. Some haue thought that the*

Magnet *would leeſe this quality attractiue, if he were annointed with garlicke, or touched with a Diamond, and of this opinion were* Ptolomie, Plutarcke, Plinie, *and* Baptiſta Porta; *for this mallady* Ruelius *hath found a remedy to annoint the* Load-ſtone *with Goates bloud, and* Paracelſus *with his oyle of* Crocus Martis, *will not onely cure him of this euill, but can make him ten times ſtronger then he was before, likewiſe* Cardanus *and* Alexander Amphrodiſeus *haue laboured to nouriſh the* Magnet *with filings of iron and ſteele.*

Many haue ſtriued much to inquire out the cauſe how the Magnet *ſhould attract iron vnto it,* Epicurus, Aphrodiſeus, Carus, Iohannes Coſtæus, Plutarke, *and* Thomas Aquinas *do ſuppoſe this attractiue vertue to proceed from certaine motes, vnſenſible parts or vapors iſſuing forth of the* Magnet, *and entring into the iron by conuenient figures, and in their retiring backe againe do attract the iron to the* Load-ſtone.

Plato *and* Fernelius *haue thought the cauſe of this attraction to be Diuine and from aboue.* Thales *and* Anaxagoras *ſay that the* Magnet *hath life in it, whereby it attracteth the like ſubſtance as liuing things do. Some thinke that there is a certaine ſympathie betweene the* Magnet *and iron, as betweene the male and female, as* Orpheus *and* Lucretius *haue ſung.*

Auaroes, Scaliger, *and Cardinall* Cuſanus *would haue iron to moue vnto the* Magnet, *as to his beginning and matrixe, from whence he came.* Gulielmus Puteanus, Galen, *and others, do iudge that by his ſubſtantiall forme he draweth iron vnto it, but Doctor* Gilbert, *whoſe labours are the greateſt, and beſt in* Magneticall *Philoſophie, doth conceiue that the* Magnet *and iron do moue one vnto the other, not by any ſpecificall forme, but from the* *eſſentiall forme of the* Magneticall *globe of the earth, being an eſſentiall part of the ſame, which is not ſo, as it ſhall be demonſtrated in the laſt Chapter of this Treatiſe.*

To illuſtrate this vertue of attraction in the Loadſtone, Serapio *and the Moores, like farre trauellers, haue reported that in the* Indies *there be mighty craggie rockes, all of* Magnet-ſtone, *that will ſtay the ſhips as they ſaile by them, and pull the iron nailes out of them; this ſtory* Olaus Magnus *alſo confirmeth to be ſo in the North, and that there, leaſt the rockes of* Load-ſtone *ſhould pull the iron workes and nailes from the veſſels and boates, they build them with wodden pins, and ſowe the boords together with lines of the barkes of trees; which indeed they do both for want of our skill in building ſhips and barges, and for want of iron-workes, whereof they haue little ſtore.*

And becauſe this ſtone hath vertue to attract, therefore Marbodeus *a French-man,* Petrus Bairus, Pictorius *and* Arnoldus de villa noua *do faine that this ſtone will procure the loue of Princes and of women, and maintaine loue betweene husband and wife.* Haly-abbas *will haue the* Load-ſtone *to cure the goute, if it be held in the hand, and the Eaſt Indians ſay that it preſerueth youth.* Cælius Calcaginus *ſaith, that if the* Magnet *be preſerued in the ſalt of the ſea-Lampron or Remora, that is thought to ſtay a ſhip vnder ſaile, that then the* Magnet *will draw vp gold that is fallen into the deepeſt well.*

And Fracaſtorius *teſtifieth that he hath ſeene a* Magnet *that would draw ſiluer vnto it, and chaſe iron from it.* Cardanus, Antonius de Fantis, Petrus Perigrinus, *and* Iohn Taiſnier *do deliuer that there might be made a perpetuall motion by the vertue of the* Load-ſtone, *but by the experience of many ingenious practiſes I find it vn-*

poſsible to be done.

Since the finding out of the Sea-compaſſe, which was about 300 yeares ago, by one Thomas Goa, borne neere Naples, or by Marcus Paulus Venetus, who learned that skill in China, as is thought, and firſt brought it into Italy, there haue growne many opinions how this Compaſſe ſhould be directed into the North and South. Marcilius Ficinus, Paracelſus, and Cardan thinke that the vertue of the conſtellation of the Beare doth gouerne the Magnet and iron, and therefore both theſe are directed into the North. Petrus Peregrinus, Frier Bacon, Iohn Taiſner, and many other would haue the Compaſſe to obſerue the North pole: But ſince that Sebaſtianus Cabotta, did find out that the Compaſſe did vary from the true meridian, it hath bene imagined that there is ſome place in the heauens that the Compaſſe ſhould reſpect, as Cardan would haue it, to obſerue the ſtarre in the taile of Vrſa major. Beſſardus, a Frenchman ſaith that it doth behold the pole of the Zodiacke, Martin Corteſius would haue an attractiue point aboue the heauens, and Robert Norman an Engliſhman, denieth that there is an attractiue point, but affirmeth that there is a reſpectiue point, to the which the Compaſſe doth moue, eſpecially the Inclinatory-needle, whereof he was the firſt inuentor.

Liuius Sanutus ſuppoſeth that there is a certaine Magneticall meridian, and Francis Maurolicus, that there is a Magneticall Iland, and Fracaſtorius holdeth that there be certaine Magneticall mountaines, which be ſet out in Plancius his Card, that the Compaſſe doth reſpect. But Doctor Gilbert, our friend and Collegiat, hath diſcouered theſe errors, and ſet forth the cauſes of the variation of the Compaſſe in his booke De Magnete.

Yet lately Gulielmus Nautonerius, a Frenchman, and

A Preface Magneticall.

Anthony Linton *an Engliſhman haue ſuppoſed that the* Magneticall-needle *and Compaſſe do moue and turne themſelues vpon the* Magneticall *meridian alwayes vnto their owne* Magneticall *poles, placed vpon the ſuperficies of the earth that be neere, and within the circles polar, not varying at all from their owne meridian, but deuiate only and decline from the meridians of the pole of the world, and with this conceit, theſe two, with many curious calculations and proiects, will preſently find the longitude of all Cities and Countries; but this their ſtrong imagination hath failed them, being grounded vpon obſeruations from the variations of the needle, from which theſe two men haue ſet forth different* Magneticall *poles; and if they ſhould worke from* 500 *obſeruations, they might geſſe at neere halfe as many varietie of poles (for variations are not regular, but irregular, becauſe their ſcattered cauſes be irregular) ſo that theſe men haue found inſteed of the longitude of places, a longitude of vnprofitable labors.*

Therefore, not purpoſing to dazell any ones conceit with the repetition and confutation of any opinions, termes of Art, or words whatſoeuer, I will come to the Tractate it ſelfe, thinking that the quiuering Magneticall-needle *will be trouble inough to handle for the better knowledge and delight in* Magneticall *experiments.*

M. R.

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MARCVS RIDLEVS CANTABRIGIENSIS IMPERATORIS RVSSIÆ ARCHIATRVS
Eta. 34 An. 1594

Miſsus ab Eliſa Ruthenis quinque per annos
Anglis ni deſis te Vocat illa domum
Tute mathematicis clarus magnetica calles
Pæonias laudes doctus Vbique capis.

To the Courteous Reader.

COurteous Reader, I haue written thee a ſmall Diſcourſe as concerning *Magneticall Bodies and Motions*, the which I hope will not be obſcure vnto thee through his breuitie, becauſe of his plaine method, and eaſie demonſtrations, which with their pleaſantneſſe will proue very ready and apparant vnto thee, eſpecially being animated from the *Magnet* ſtone it ſelfe, as from a moſt liuely and perfect teacher: Therefore I would aduiſe thee, that when thou readeſt this booke, that thou wouldeſt prouide thy ſelfe of ſuch like formes of *Magnets* as I haue deſcribed in the firſt Table and figures of the ſecond chapter, as alſo of needles, wiers, and waights of iron and ſteele, ſet forth in the ſecond Table of the third chapter of this booke, which thou mayeſt haue made and prouided for thee by the helpe of ſome skilfull workemen: when thou ſhalt be furniſhed with theſe kinds of prouiſions, then thou mayeſt reade and practiſe the operations and demonſtrations of this booke, which will be both eaſie and very pleaſant vnto thee; and though that there be many precepts and practiſes in this Booke, which be not for example ſake ſet downe in tables and figures vnto thy ſight, becauſe I deſired to be very briefe, yet if thou ſhalt not be altogether vnskilfull in theſe demonſtrations that be delineated in the Tables of this booke and their often practiſe, thou wilt be able inough to vnderſtand and put them in vſe, with theſe forenamed prouiſions. But if thou ſhalt deſire, beſides thy inſtruction in this kind of learning, to put in vſe and make benefit of theſe matters *Magneticall*, either in trauelling or ſailing vpon the *Magneticall* globe of the earth, then it will be very neceſſary for thee to be ſtored with the Marriners Compaſſe for the ſea, perfectly drawne and framed, to know the way, and of what hand and point to ſaile and trauell, and alſo to haue the *Inclinatory-needle* truly placed in his ring, and a *Directory-needle*, or a little flie *Magneticall* in the boxe, faſtened at the bottome in his conuenient diſtance, for to know vnder what latitude thou art euery day of thy voyage: Likewiſe if I ſhould declare vnto thee how beneficiall the *Directory-Magneticall-needle* is for the deſcription of Ports, Hauens, Forlands, Capes, Bayes and Riuers, for the more perfect making of Sea-cards, how neceſſary for the poſiture of buildings, directing of dials, and all Mathematicall inſtruments for meaſuring and ſurueying, for pioners and vnderminers of forts, for ſearchers of minerals, mettals, ſea-coles, and other ſubtereſtriall bodies, I ſhould be too tedious vnto thee, and will rather referre thee for theſe matters to that which is ſet downe by others, becauſe I meddle here in this booke onely with thoſe things that be *Magneticall*.

In this place I thinke good to aduertiſe thee as concerning the magnitude of the ſeuen Planets, with their reſpect vnto the earth, out of *Ticho Brahe*, deſcribed in the top of the Title Page; that whereas their proportion cannot be ſet forth truly in any types, being at too great oddes: therefore I haue deciphered that in figures; as let the *Earth* ○ be but one part, the *Sunnes* ☉ greatneſſe will be 140 times ſo much; *Saturnes* ♄ 22, *Iupiters* ♃ 14. And if that *Venus* ♀ haue 6 parts, the *Earth* will haue 37 parts, if *Mars* ♂ be one part, the *Earth* is 13, if *Mercury* ☿ be one part, the *Earth* is 18, if the *Moone* ☽ be one part, the *Earth* will continue her 42 times. Beſides, I haue drawne the *Axis* in the greater Planets, as being bodies *Magneticall*: for I truſt that theſe following times will diſcouer whether they be paralell one to the other, or no, as alſo what naturall motions elſe they haue, becauſe that *Aſtra natant, auis inſtar in aëre, aut piſcis in vnda*, and here it might be ſayd that we hope that many new points in Philoſophy and Aſtronomy will bloſſome and ſpring out of this kind of learning hereafter,

Thine in all affection,

M. R.

A SHORT TREATISE OF MAGNETICALL BODIES AND Motions.

CHAPTER I.

Of Bodies Magneticall.

THAT we define to be a *Magneticall body*, which ſeated in the *æther* or *aire*, doth remaine and place it ſelfe in one place or kind of ſituation naturall, not alterable; as all ſtarres do, and the great regent Globes of *Saturne*, *Mars*, *Iupiter*, the *Sunne* and the *Earth* do; or ſuch as with reſpect and attendance follow other Globes, as the two ſtarres which ſupport *Saturne*, the foure attenders vpon *Iupiter*, lately diſcouered by the trunke ſpectacle, the two traueſers about the Sunne, called *Venus* and *Mercury*, and laſtly the Moone, which doth follow, or go about the Earth, and reſpecteth the ſame alwayes with one pole: and therefore hath a peculiar *Magneticall* vertue that guideth her in this kinde of ſituation.

All *Magneticall Globes* haue ſome parts of their bodies which be alſo *Magneticall*, which being ſeperated from their proper globes, and no way hindred, will ſeate themſelues or be ſeated vnto the naturall ſituation of their particular Globes.

The *Earth*, whereon we liue and moue, hath two minerals that be *Magneticall*, the one is the *Magnet* or *Load-ſtone*, which draweth iron vnto it, and this iron or ſteele is the other. Either of theſe two being conueniently, and artificially placed in the aire, or in a boate on the water, freed from all obſtacle and renitency, will place and reſt certaine parts of themſelues, which be called the poles of their body, reſpondent vnto the poles of the Earth, which ſituation we call North and South, becauſe they be parts of the *Magneticall* globe of the Earth, who by her attractiue and diſponent vertue, doth thus direct and ſituate them.

CHAP. II

Of the Magnet ſtone, his forme and caps.

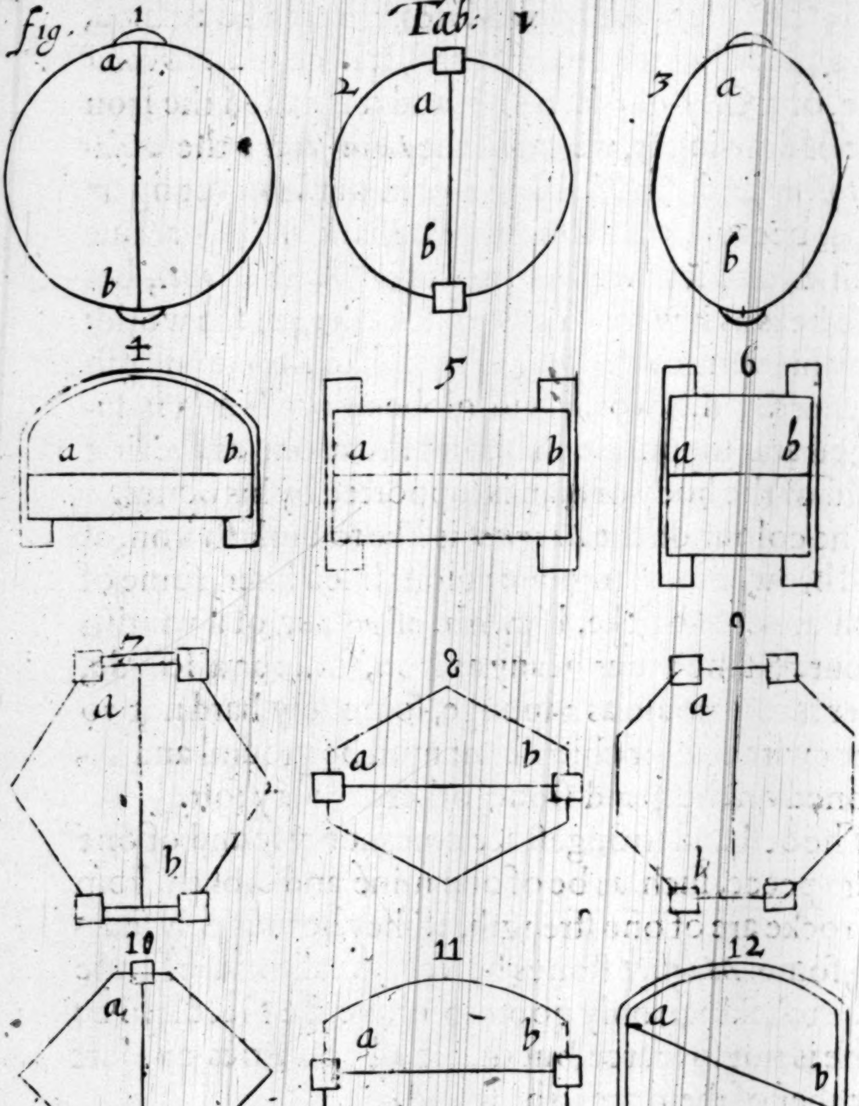
THe *Magnet* ſtone is heauie and maſſie, like vnto iron, hauing much ſteele and iron in it, this ſtone will attract, hold, diſperſe, and compone like a little earth other leſſe *Magnets* and *Magneticall* formes of iron and ſteele to his conformitie of *axis* and poles. This ſtone is called the

Magnet, of a countrey in MACEDONIA ſo termed, where plenty of them are found, it is called *Hercules* ſtone, of a City of that name, and it is called the Iron ſtone of drawing it, we call it the *Load-ſtone*, the *Adamant ſtone*, and the *Oſmound ſtone* in our Iron-mongers ſhops; becauſe of his leading directiue and attractiue qualitie, and it is well termed the *Oſmound ſtone*, becauſe he is as it were *Os mundi*, the bone of the world: for by his vertue *Magneticall* he is like a bone and pillar whereby this world and globe of the Earth is ſuſtained and ſupported in his iuſt ſituation, as the litle world of the body of man is ſupported by his bones.

The colour of the *Magnet* is like to duskiſh iron, of a ſad browne and ſanguine colour like a liuer, ſome of them are cole-blacke, blewiſh, aſhey, or of a whitiſh colour. Some are as heauy as iron, firme and ſollide, other rare porouſe as a ſpunge, ſome very hard not to be cut with axe or chiſell, but muſt be ground and faſhioned on the grind-ſtone, other are very ſoft.

The beſt and ſtrongeſt are commonly found of one intire peece, ſuch as be of one mine and broken from the rocke are of one ſtrength, if they be ſuddenly ſeuered; ſome *Magnet* ſtones be very weake and of little force to take vp, only good to moue the Needle. The ſtone is not ſo ſcarce, but that in all countries one ſort or other of them are to be found.

It is very conuenient and neceſſary for diuerſe vſes and demonſtrations to haue the *Load-ſtones* ground and formed by the grind-ſtone: or otherwiſe ſawen with ſand and emery into diuerſe formes, faſhions, and figures, and after by the Cutter of precious ſtones to be finely poliſhed: and alſo artificially capped and armed with ſteele, or iron, by the hand of ſome inge-



nious Smith.

The firſt forme of the *Magnet*, which I offer vnto your eyes, *Table I. Fig.* 1. is a large one, in faſhion of a round ball, boule or globe, and we do call it a *Terrella*, or little earth,becauſe that vpon this figure of the body of the *Magnet ſtone*, we ſhall hereafter ſhew how to find naturally the poles and the reſt of the circles of the Spheare, prouing vnto your eyes all kinds of *Magneticall* demonſtrations on it,and ſhall after, moſt fitly and naturally, declare how to obſerue them in trauelling or ſailing vpon the great *Magneticall* globe of the earth. This forme may be artificially capped and armed with ſteele,or iron,at his two poles, *Tab. I. Fig.* 1. *a b*, for to take vp iron waights, or to touch *Magneticall* needles withall.

The next faſhion is a round and flat forme, of a reaſonable thickneſſe like a coite, cake, halfe boule, Holland-cheeſe,or part of a columne, *Table I. Fig.* 2. and may be called a *Semiterrella* his poles, *Tab. I. Fig.* 2. *a b* muſt be ſituated in the middeſt of the ſides of the roundle. This forme may be capped artificially at either pole, *Tab. I. Fig.* 2. *a b* with two ſquare teeth of iron, *Tab. I. Fig.* 2. *a b*, deſcending at right angles to the line of the *axis*, *Tab. I. Fig.* 2. *a b*, and this is almoſt as conuenient as the former in the firſt figure of this firſt Table for all *Magneticall* demonſtrations, which are performed onely vpon a Meridian circle that paſſeth by the two poles, which this forme hath. And the ſtone for this forme is more readily procured then that is of the firſt and globous faſhion.

The Oual and long forme like an egge, *Tab. I. Fig.* 3. is thought to be the beſt faſhion, by ſome, for to touch the needles of the ſea Compas withall, and to take vp waights at one end, *Tab. I. Fig.* 3. *a b*, becauſe he hath a long diameter line, *Tab. I. Fig.* 3. *a b*.

The long egge forme flatted at the bottome with two iron teeth from the two poles, *Tab. I. Fig.* 4. *a b*, as the *Semiterrella* hath, *Tab. I. Fig.* 2. *a b*, the ſquare formes with foure teeth from the two poles, *Tab. I. Fig.* 5 *&* 6. *a b*, two teeth at one end, all theſe are very fit faſhions to take vp great waights, and to touch *Magneticall* bodies and inſtruments withall, as ſhall be hereaftet ſet foorth.

There be many other faſhions that may be inuented and wrought at pleaſure of the Cutter, or as the *Load-ſtone* will be fitteſt for, as the ſixth ſquare, *Tab. I. Fig.* 7. the ſixe angles vnequall, *Tab. I. Fig.* 8. The foure angles, *Tab. I. Fig.* 10. and of many other faſhions, as *Tab. I. Fig.* 9. 11. 12. which may be deſcribed, all which being flatted or rounded at their poles, *Tab. I. a b*, hauing their caps with one or two teeth, will take vp by them both, or ſeuerally, and are good to touch needles, wiers, kniues, daggers, and ſuch like long formes, to giue them vertue to take vp ſmaller wiers, ſowing-needles and ſuch like ſmall waights, or to giue the vertue polar.

You may cap and arme ſome kinde of formes of *Magnets* with foure teeth, two teeth from the ſide flatted at either pole, as we haue deſcribed *Tab. I. Fig.* 7. which hath foure ſquare iron teeth, like a foure footed ſtoole, to raiſe vp waights with foure teeth together.

If you had a *Magnet* ſtone of a flat forme, that had his poles in the center of the ſtone, as theſe I haue deſcribed haue their poles in the ends, then you might place one ſide with his pole downeward, and the other ſide vpward, and prouide you a cap for the vppermoſt ſide, like a Greeke P Π, and a cap for the nethermoſt ſide like a Slauonian T Ⱅ, and theſe being artificially and diſcuſſiuely faſtened to this *Loadſtone*, would take vp waights with fiue teeth, as it were an hand with fiue fingers.

I haue drawne a line *a b* in all theſe formes, paralell to the *axis* of the *Loadſtone*, to the end that the caps of iron, croſſing the poles and *axis a b* at right angles, may be the better perceiued.

Neuertheleſſe, in faſhioning of ſome *Load-ſtones*, the *axis* cannot ſo aptly be alwayes placed in the midſt of the ends of the *Load-ſtones* being flatted, vnleſſe there be a greater part of the *Load-ſtone* taken away, & the bulke very much deminiſhed, which will leſſen much the ſtrength of the ſtone: for the greater that the bulke is, the more is the ſtrength of the *Magnet*.

Therefore I haue ſet downe a type in the laſt place, *Tab.I. Fig.12.* where the diamiter *a b* lieth awry, and the poles be ſituated higher and lower at the ends, and yet the *Loadſtone* ſhall take vp as much in waight as if his diamiter lay not obliquely.

The hilly knobs and angulous parts of the *Loadſtone* may be ſawen away with ſand or emery, without any hurt to the vertue of the ſtone, and ſometimes many ounces may be cut away without any loſſe of *Magneticall* vigor, eſpecially if any ſubſtances of other nature be intermingled and agglutinated to the *Magnet*, which may be knowne by their colour and hardneſſe very eaſily.

Alſo, if there be any cauities and hollow places, or broken parts of the *Loadſtone* that do diminiſh his vertue, or disfigure his forme, this may be ſupplied, mended and filled, either with a peece of another *Loadſtone*, or with a cement of the powder of the *Loadſtone*, and the filings of ſteele or of iron brayed and grinded very ſmall vpon a painters ſtone, mixed with rozen and waxe, melted and coloured to the colour of the *Magnet* that is mended, putting into this cement more or leſſe of the filings, according to the ſtrength of the *Loadſtone.* Some with this cement, and ſuch like glutinous matter, make diuerſe formes of *Magneticall* bodies artificiall.

It is very conuenient for makers of ſea-compaſſes, and maiſters of ſhips to haue a *Magnet* well capped, that taketh vp at one end halfe a pound waight at leſt, for it is not wholly neceſſary that the ſame ſhould be of the beſt vigour and ſtrongeſt rocke: for all *Loadſtones*, both of great and leſſe vigour, haue the ſame facultie *Magneticall* to all intents and purpoſes. The greater ſtones of the ſame rocke haue a larger vertue then the leſſe, and euery part and ſmall peeces of *Magnet* ſtones haue euery one of them the ſame vertue and vigour *Magneticall* the great ones haue, ſauing that they be more weake, and not alwayes proportionable in ſtrength vnto them.

CHAP. III.

Of Iron.

IRon is a mettall decocted out of the *Loadſtone*, or out of a mine of that kind. The beſt iron-mine and *Loadſtone* is all one thing and body *Magneticall*, for it being placed artificially, either in the aire or vpon the water, moueth North and South, attracteth other iron vnto it, and performeth the ſame concluſions that the *Magnet*

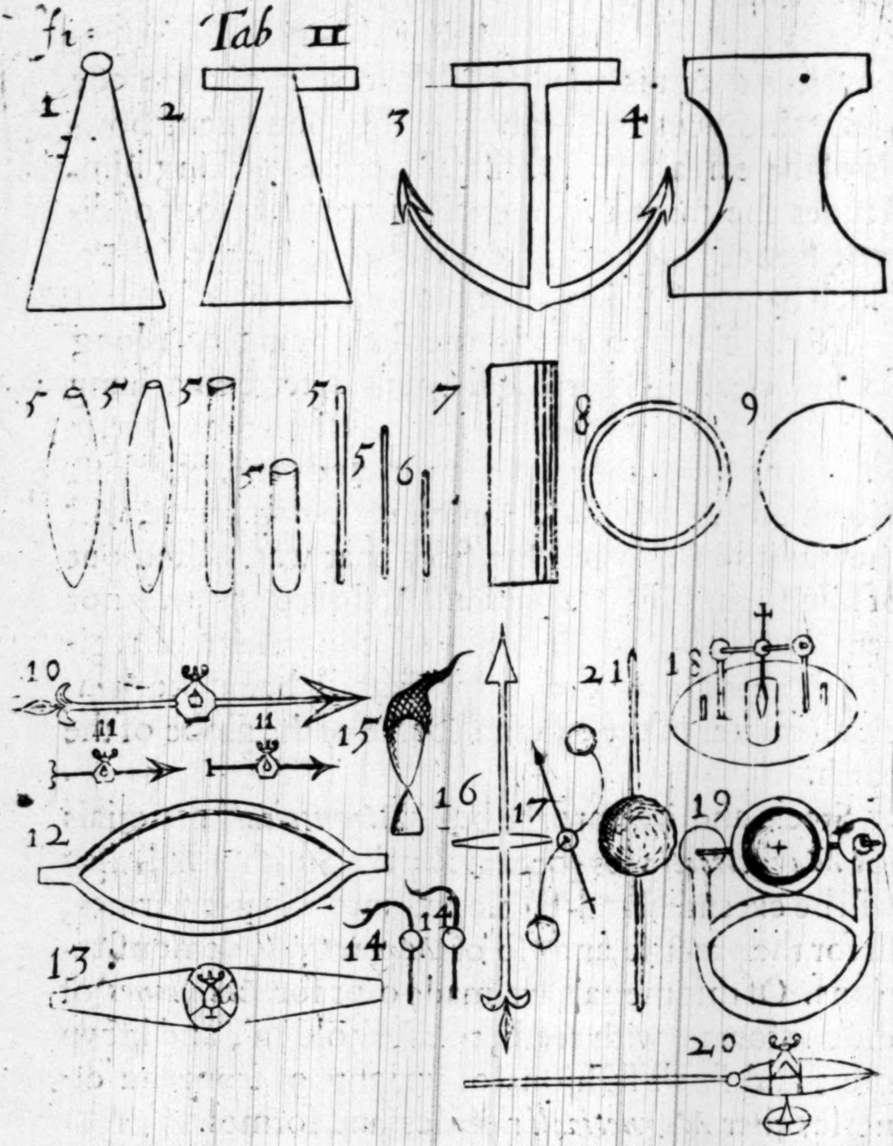
net ſtone doth.

This mettall is heauie and of a blewiſh blacke colour after that it is tried from the droſſe, and is made of certaine iuces and vapours in the conuenient bowels of the earth by a ſpecificall vertue working him. Beſides the mine this mettall is excocted out of diuerſe ſtones, ſands, earths and clayes of diuerſe colors, which haue much Iron-like matter in them.

If ſome clay be burnt in the fire, being of a long forme, cooling North and South, after being hung on a thrid in the aire, or put into a diſh in the water, it will turne and moue it ſelfe too and froe, till it reſt North and South, and ſome clay being burnt, will ſhew a little iron vpon his ſides that was melted out of him, ſo that this *Magneticall* ſubſtance of iron is not very ſcant to be found: for in all countries and regions there is great ſtore of this mettall, being the principall matter of the externall barke of the globe of the earth.

Steele and iron are the beſt *Magneticall* materials for *Magneticall* vſes; becauſe by the Smithes skill they will be extended and faſhioned into diuerſe formes, fit for the practiſe and vſe of *Magneticall* demonſtrations. Of this mettall are made caps for *Loadſtones* of diuerſe formes with teeth, to take hold of, and lift vp great and ſmall faſhions of waights of iron, and diuerſe other *Magneticall* needles and formes.

Waights of iron are made of diuerſe formes, as long and narrow at the top, *Tab. II. Fig.* 1. to be taken and lifted vp at one end of the *Loadſtone*, and with one tooth. Others haue an headleſſe croſſe vpon the waight, as *Tab. II. Fig.* 2. long, and finely ſmoothed aboue, that the *Loadſtone* may take the better hold with



both his teeth. Some greater waights may be made in faſhion of an ankor, *Tab.II. Fig.3.* with a croſſe head, or in forme of a ſithe, *Tab.II. Fig.4.* alſo you are to haue in readineſſe longer formes of iron and wiers, great and ſmall, as in *Tab,II. Fig.5.* to apprehend alone, or one at the ende of another: alſo very ſmall wiers of iron, the length of a barly corne, *Tab.II.Fi.6.* are fit to ſet vpon the *Magnet*, for diuerſe intents and purpoſes.

It is good to haue long plates of iron reaſonable thicke, *Tab.II.Fig.7.* round plates of iron, *Tab.II.Fi.9.* and round rings of iron of diuerſe weights and bignes, *Figure* 8.

It is conuenient to haue diuerſe directory *Magneticall* needles, great and ſmall, *Tab.II. Fig.*10.11. for dyals and inſtruments, and needles for Compaſſes, *Tab.II.Fig.*12. & 13. to faſten to the Cardes, or to take off at pleaſure: we vſe ſhort wiers faſtened to thrids; and a little *Loadſtone* in a thrid to take vp a waight.

Alſo it is neceſſary to haue *Inclinatory-needles*, *Tab.II.Fig.*16. to put into his ring, and a ſhort one with a Lute-ſtring in the middeſt, *Tab.II.Fig.* 17. or elſe put in a frame of braſſe or ſiluer, as *Tab.II.Fig.*18. to find the pole of the *Loadſtone*, and to demonſtrate his oblique inclination to the *Loadſtone*, as he is caried about him, or elſe to haue a little round *Loadſtone* put into a frame with an axletree, hauing his poles marked *Fig.* 19. which applied about the *Loadſtone*, turneth and conuerteth it ſelfe diuerſly, alſo it is fit to haue a ſhort and thicke needle, *Tab.II.Fig.* 20. into the end of it, there is to be put a wier of ſiluer, braſſe, or of a peece of a Whale-bone, for vſes hereafter to be declared. Alſo a long wier thruſt through a corke, *Fig.*21. ſerueth for *Magneticall* vſes in the water. Theſe formes of iron, with others that the ingenious will eaſily inuent and make, are very fit for *Magneticall* demonſtrations, as well as the variety of *Magnet* ſtones are.

CHAP. IIII.

Of the Earth.

THis great Globe of the Earth whereon we moue and trauell, is found to be a *Magneticall* body, by ſuch as haue trauelled and ſayled round about her, as Sir *Francis Drake* did, and M. *Candiſh*, whoſe *Magneticall* Compaſſes were alwayes directed *Magnetically*, that is, the Lilly of their Compaſſes was turned alwayes towards the North-pole in all places whereſoeuer they ſayled, by the vertue *Magneticall*, and diſponent faculty of the *Magneticall* Globe of the Earth, as it is demonſtrated in the XXV. Chapter of this Booke. Alſo by ſuch as haue made their courſe northerly and ſoutherly, it hath bin obſerued that the *Magneticall Inclinatory-needle* doth in euery eleuation of the pole conforme and apply it ſelfe, or rather is conformed and diſponed vnto the *axis* of the Earth, according vnto certaine correſpondent angles to the Latitude, as it is demonſtrated in the XII. XIII. XXXV. & XXXVI. Chapters of this Booke, whereby it is demonſtratiuely to be concluded, that the Earth is a *Magneticall* body, directing both her ſelfe and the other two *Magneticall* bodies into the North and South, by the vertue of her Meridian circles and parts, as is demonſtrated in the IX. chap. and others.

Moreouer, the Earth hath naturally two *Magneticall* poles; vnto the which theſe meridionall parts do direct, bend & force, not only *Magneticall* bodies neere the Earth; but alſo her owne mighty and maſſie ſituation, ſtability and firmeneſſe, and ſeateth her ſelfe ſo ſtrongly vpon her two poles, by her naturall and *Magneticall* vigor, paſſing from her meridionall parts to the poles, as if ſhe were tied by many mighty ſtrong cables vnto two moſt firme pillars, farre ſtronger then any *Hercules* pillars; not to be remoued by any force from her naturall poſition; which thing, if it might chance that it ſhould come to paſſe, yet certainely ſhe would returne againe vnto her former firme ſeate and place, as all *Magneticall* bodies and directory needles do, as is demonſtrated hereafter.

Thus we proue that the Earth is placed and firmed by her *Magneticall* vertue, and not by her grauity and waight, though that the parts of the Earth do conioyne and adhere together by their grauity mouing to their Center. But the *Magneticall* nature moueth, conformeth, and firmely ſeateth it ſelfe to the poles and *Axis*.

Now for that the poles of the Earth do alwayes, by their natural vertues hold the Earth North and South in one certaine and vniforme ſituation, eleuation and place, there is no doubt but that the whole globe of the Earth, inwardly ſtored with many materials and rich minerals, & outwardly adorned with many trees and excreſcences, all for the vſe of man, with liuing creatures innumerable, as alſo in reaſon it is an vnfallible certainty, that the Earth hath, at her firſt creation, beſtowed vpon her a globous and ſtarlike vigor, or intelligence, whereby ſhe may, hauing her whole parts vnited together, by the vertue of grauity vnto the center, and her place made ſure *Magnetically* by her poles vnmoueable; yet moue naturally, keeping her place circularly & diurnally out of the Weſt into the Eaſt, to the end that all creatures ſhould receiue the comfortable and liuely beames of the Sunne, and the influences of the reſt of the Planets and Starres.

This motion many learned men haue attributed vnto the Earth, for the benefit of calculating the motion of the Planets the better, which naturally ſhe hath in her ſelfe; for euen as it were needleſſe for a wheele to haue her naue, ſpokes and rimme about her, if it ſhould not be vſed to turne about; ſo it were to no purpoſe that the Earth ſhould naturally haue a globous body, two poles, an *axis*, meridians and æquator, as ſhall be demonſtrated hereafter, parts fit for circular motion, and not for to turne her æquator and paralels about, as the wheele doth.

Although theſe arguments will hardly perſwade vs to beleeue the earths motion; yet becauſe that it is lately obſerued vnto our ſences by helpe of the truncke-ſpectakle, both by *Galileus* and *Kepler*, famous Mathematitians, that the great body of the globe of *Iupiter*, being twelue times greater then the Earth, doth turne about in leſſe time then a day vpon his *axis* and poles, who alſo haue obſerued foure Moones, attendant on *Iupiter*, which moue round about him, the ſloweſt in 14 dayes, the next in ſeuen dayes, and the reſt in ſhorter time. So likewiſe *Iohn Fabricius* hath obſerued, that the great globe of the Sunne, hauing three great ſpots, like continents in him, and being ſixty times greater then the Earth, to moue about his *axis* and poles neere the time of ten dayes, or thereabouts, ſo *Galileus* and *Kepler* haue ſeene the Planet of *Venus* to moue about the Sunne in ten moneths, and to haue her light from the Sunne in this time increaſed and diminiſhed vpon her body, as we ſee the Moone here neerer vnto vs to haue; therefore it being certaine by obſeruation, that the globe of *Iupiter* and the Sunne do turne about their *axis* and poles, whoſe materials we know not, we need not doubt that the Earth ſhould haue a circular motion for her great good. But how the Earth doth turne circularly we cannot well ſee it, with the ſence of our eyes, vnleſſe we had them placed in another globous body and ſtarre, as if they were in the Moone, where we might ſee the ſpots of the Earth to turne about, as well as now we ſee the ſpots in the Sunne, and *Iupiter* to moue circularly in their place. And as contrariwiſe our eyes here on the Earth do ſee that the Moone doth not turne about, by the placing of her ſpots, alwayes in one faſhion vnto vs: for we may obſerue with our eyes, that the Moone hath poles of a kind of *Magneticall* nature, which do alwayes hold her to behold the center of the Earth, and ſo ſtayeth and conformeth her, that howſoeuer ſhe moue, higher or lower, or whereſoeuer ſhe be, yet alwaies the ſpots of halfe her globe be alike apparant vnto our eyes, and conforme her to behold the center of the Earth with one pole: neither doth the Moone turne about her body vpon two poles, as the Earth doth vpon hers, but is kept firme and vnmoueable from circular motion, about her *axis*, by other two poles that be vpon the edges and æquator of her body, becauſe her ſpots be alwayes alike on her Eaſt and Weſt ſide, that hold her firmely & ſtiffely that ſhe can by no meanes turne about vpon her firſt two poles: For it is the vertue polar and *Magneticall* that holdeth all globes in their poſition whatſoeuer. Beſides, the Moone hath another vertue giuen her at her firſt creation, whereby beholding alwayes the center of the Earth, and mouing neerer and further from the Earth, as tied with an axletree, ſhe moueth, ſlideth, and paſſeth monethly about the Zodiacke, that all the parts of her globe may be illuminated and refreſhed with the beames of the Sunne, and influences of the Starres: for as a ſhip vpon the water is directed euen forward by the ſterne and ruther, which hath not only a right line to direct forward, but alſo a right angle deſcending downewards, that ſhe waue not ſidelings or turne about; yet hauing this poſition, if ankors be layd out, either forward, or backward, or ſidelings, with their cables on boord, if there be force or vertue on boord to hale forward, ſhe moueth forward, if drawne backward, ſhe goeth backward, if pulled by the cable on the left hand, yet keeping her poſition, ſhe betaketh to that hand, and ſo to other parts. Euen ſo the Moone being ſeated, as afore is ſaid, doth moue on her *axis*, higher or lower, on this ſide or on that, according to the vertue & ſtrength of the multiplicity of her axletrees, being her limbes to ſtay and moue withall, as the body hath armes and legges, with variety of muſcles to moue on all hands.

But the Earth, whereon we liue and trauell, hath neuer bene found by any to haue any poles in the æquator of her body, or neere the ſame: for if we were ſo happy to find any in the Eaſt or Weſt of the earth, then the matter of longitude would be perfectly attained vnto, which hath ſo greatly buſied all the ingenious wits of the world: and therefore we affirme that the Earth doth turne about, becauſe there are no poles in the æquator to hinder her, as there is in the

Moone from circular motion. But leauing theſe motions to others that do labour more therein, here in this booke I purpoſe onely to intreate of the great globe of the Earth, as ſhe is a *Magneticall* body, which ſhall be firſt performed, by way of imitation, in a little *Magneticall* earth, or *Terrella* and *Semiterrella*, made of a round *Loadſtone* and Adamant, whereby we ſhall plainely and ſenſibly demonſtrate, that there be two poles, an *axis*, meridians, paralels, and an æquator in euery *Loadſtone* and *Magnet*, and we ſhall produce many other pleaſant demonſtrations, manifeſt Theoremes, and ſenſible practiſes vnto your eyes and vnderſtanding, which we ſhall after illuſtrate to be in the globe of the Earth, to proue it to be a third *Magneticall* body, different in ſubſtance from the other two *Magneticall* bodies, ſpoken of in the two former Chapters.

CHAP. V.

Of the two Poles, and how theſe points are found out.

THe ancient Mathematitians and Aſtronomers of formes times, obſeruing the diurnall motions and apparences of the Planets and Starres, fained certaine fixed poles, and other circles in the heauens, by which they diſcourſed of the riſings, ſettings, motions, and of the places of the planets and ſtarres; neuer imagining that theſe fained matters were naturally and ſenſibly to be found in the globe of the Earth, much leſſe to be ſeene naturally, and in a round *Loadſtone*, and in all other formes of the *Magnet* ſtone, being long ſeuered and kept from touching and couching in the bowels of the Earth.

I will firſt proue how the two poles are found out in the *Magnet* ſtone, which are very neceſſary to be knowne, before that the *Load-ſtone* be faſhioned into any forme, for the better proportioning of the ſame; and this matter may be accompliſhed ſixe or ſeuen manner of wayes.

1. The firſt way is to role the *Load-ſtone* in ſmall and cleane filings of iron, and about thoſe parts where the points and poles be, there the filings will cleaue faſt in great multitudes, and at the pole will ſtand and be erected vpright, marke theſe places with Chalke, Tripoly, Red-oker, or with an hard file for the poles.

2. The ſecond way is to hang a ſowing-needle by a thrid, or a ſmall wier, *Tab. II. Fig.* 14. or as in *Table III. Fig.* 1. ouer thoſe places of the *Loadſtone* whereabout the poles are likely to be, and the needle and wier will moue from his perpendicularity, and hang directly ouer the point, and deſire to touch the pole. So likewiſe, if there be a ſmall peece of a *Load-ſtone*, *Tab. II. Fig.* 15. cemented to a thrid, and held ſo that one of his poles bend downewards, and it will affect to touch and to vnite it ſelfe to the contrary pole in the ſtone.

3. Thirdly, take the needle of a dyall, or ſome of the directory needles, before deſcribed, *Tab. II. Fig.* 10. & 11. place the ſame, being touched *Magnetically* vpon his pin or ſtake, *Tab. III. Fig.* 1. then turne the *Load-*

ſtone round about, holding it ſomewhat neere vnto the needle, and it will point at the pole of the *Magnet*, deſiring to touch it.

4. Fourthly, take a peece of ſmall wier, of iron or ſteele, ſuch as is made for Virginall-ſtrings, *Tab.II. Fig.6.* and cut off a part as long as a barley corne, and ſet it vpon the *Load-ſtone*, and it will ſticke faſt at one end vnto it, but erect it ſelfe at the other end, and being put forward, will ſtand vpright onely there, where the pole of the *Magnet* is, *Tab.III. Fig.2.*

5. Fifthly, take a little *Inclinatory-needle*, before deſcribed, *Tab.II.Fig.17.* that hath a Lute-ſtring put through him, or take that *Inclinatory-needle* which is placed on a frame, and borne vpon an *axis*, *Tab.II.Fig.18.* and cary either of theſe round about the *Loadſtone*, and they will conforme themſelues obliquely vnto the ſtone, and onely at the poles will direct the points of their ends perpendicularly ouer the ſame. Alſo take the litle round *Magnet*, before placed vpon his axletree and frame, *Tab.II.Fig.19.* hauing his two poles marked, and this ſtone will turne and conforme it ſelfe to the *Loadſtone*, and apply his contrary pole directly ouer one of the poles of the *Loadſtone*.

6. Sixthly, place a ſmall wier vnder the *Loadſtone*, and it will follow to the pole thereof, and cleaue and hang to the pole it ſelfe, which is to be marked.

7. Seuenthly and laſtly, take that wier that is thruſt through a corke, *Tab.II.Fig.21.* and put it in water, holding a *Loadſtone* vnto it, and it will draw neere, and bend it ſelfe to ioyne to the pole of the *Magnet*.

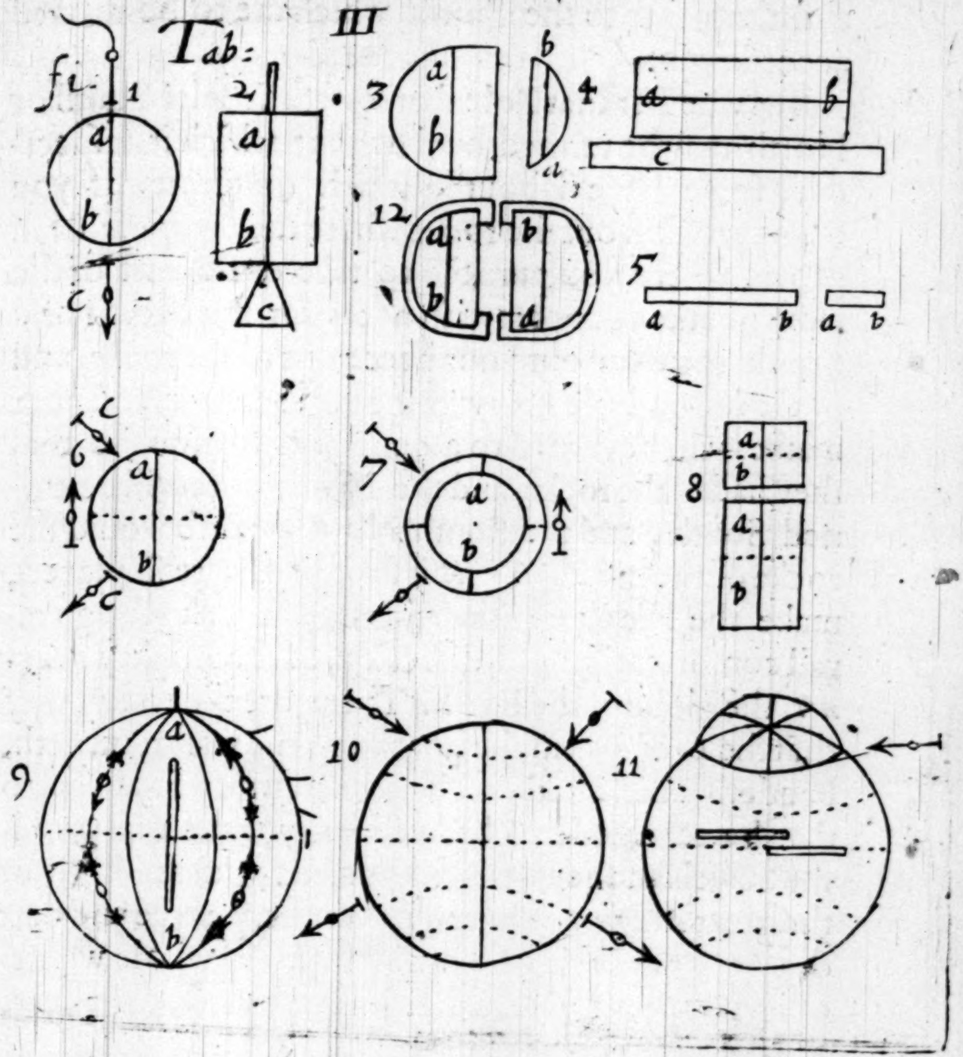
If a ſtone be diuided and ſawen in two parts from one pole to the other, or by a paralell, *Tab.III.Fig.3.* the poles will be in their paralell place, *Tab.III.Fig.3.*

a b, and are to be found in the middeſt of the ſubſtance of the *Loadſtone*, vnleſſe they be drawne aſide by excreſcenſes and leuities.

CHAP. VI.

Of the vertue of the Poles.

THere is no one part of the *Loadſtone* that hath ſo great a vertue to attract, lift vp, and conforme *Magnetically* as the Pole hath. And although that ſome haue declared that all the parts of the *Loadſtone*, from the æquator to the Pole, doe beſtow their vertue and ſtrength vpon the Pole; yet if triall be made what the Pole will take vp perpendicularly, and alſo what the parts about 34 degrees will lift vp, it will appeare to be more then halfe as much perpendicularly, ſo that the Pole doth not take vp ſo much as this, and the other part doth on the other ſide. Neither is it certaine that, according to the largeneſſe of the cord in the arch, the attraction ſhall be in ſtrength: for then the middle cords would be very ſtrong, and ſtronger in lifting vp then the other; becauſe their cords are curtalled at the æquator, which deuideth the *Loadſtone* into two natures. But becauſe *Magneticall* bodies do moſt apply and conforme themſelues vnto the Poles, & make one ſtraight *axis* with the center of the *Magnet*: therfore the attraction and apprehenſion at the Poles, is more ſtrong then it is in other paralell places of the ſtone, where the *Magneticall* bodies conforme and



apply obliquely vnto the *Terrella*, whereby the attraction and apprehenſion in the ſpaces neere the æquator is weaker, and lifteth vp leſſer waights.

Magneticall bodies haue two poles or points, the one is North, and the other is South, which be knowne either by hanging a *Loadſtone* leuelly in a thrid, or putting it in a wodden diſh to ſwim in a baſen of water, and then the one Pole will alwaies turne to the North, and the other to the South, which are to be marked accordingly.

But whether that Pole that ſeateth it ſelfe South or North may be termed by that part which it reſpecteth, ſome haue laboured much to cleare. If you chance to find out the rocke where the *Loadſtone* doth grow, where you purpoſe to take out a part of the ſame, marke your part with notes for the North and South, then cut out your peece out of the rocke, and put it into a bole to ſwimme on the water, and your markes will be turned to a contrary ſituation, to that they had in the rocke, and the North note will be turned South, and the South North, and ſo would the rocke of the great *Magnet* it ſelfe, if it were ſo placed, make the like alteration in his ſituation, by the generall conformation and direction of the mighty *Magnet*, the globe of the Earth. Therefore the reaſon why that the *Loadſtone* in the boat vpon the water, turneth, bendeth, and ſeateth it ſelfe to a contrary ſituation, to that he receiued and had primarily, whileſt he was in the bowels of the Earth, and vnited with the body of the great *Magnet*, is becauſe that euery peece and part of a *Load-ſtone*, being ſeperated from the whole whereof he was a part, is now become a perfect, complete, and ſole *Magneticall* body, and is as it were, a little earth of it ſelfe, hauing all the proprieties *Magneticall* that the great Earth hath, as his two poles, meridians, æquator, and ſuch like: and therefore according vnto the nature of *Magneticall* vnion, hereafter ſpoken of in the XXII. chapter, will in no wiſe indure, and cannot be ſuffered to match and ſeate it ſelfe as he did before, but thinketh it more naturall, and a thing of more perfection and conueniency to turne his aſpect a contrary way, to that he had primarily at his firſt making and endowement with *Magneticall* vertue.

This alteration of polity is to be obſerued likewiſe in *Magneticall* needles, and long peeces of iron that be touched, and animated, and adhere to that part of the *Load-ſtone*, which ſeateth it ſelfe North, which being at liberty and ſeperated from the *Loadſtone*, will turne that part and end that was touched at the North pole, and ſeate it alwayes in the South, and it ſhall be ſufficient for vſe to know and marke with a note which is the North-pole of your *Magnet*, and which is the South-pole.

There is another vertue in the Poles of the *Load-ſtone*, and that is, that the South-pole turned downeward, will take vp more then the North-pole will, and the North pole will erect a greater waight then the South part or pole will, as ſome ſay, *Tab.III.Fig.2. a b*. But I haue alwayes obſerued, that the Pole of the *Magnet* that ſeateth it ſelfe North, is alwayes the moſt vigorous and ſtrong Pole to all intents and purpoſes: vnleſſe he lacke the quantity and like ſubſtance the South part hath.

Theſe Poles which be in the great *Magnet* of the globe of the Earth, haue a maruelous ſtrong *Magneticall* power imparted vnto them, that they cannot be turned either higher or lower, or moued to the right hand or to the left, but hold the Earth continually in a true and certaine poſition and place, and would if any force or power ſhould moue their great ſtrength awry from the true ſyte and meridian latitude, returne to their right ſyte and place againe, and this is the true vertue of the Poles of globes, which the Sunne and *Iupiter* haue as well as the Earth.

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There is another vertue in the Poles of the *Loadſtone*, and that is, that the South-pole turned downeward, will take vp more then the North-pole will, and the North pole will erect a greater waight then the South part or pole will, as ſome ſay, *Tab. III. Fig.* 2. *a b*. But I haue alwayes obſerued, that the Pole of the *Magnet* that ſeateth it ſelfe North, is alwayes the moſt vigorous and ſtrong Pole to all intents and purpoſes: vnleſſe he lacke the quantity and like ſubſtance the South part hath.

Theſe Poles which be in the great *Magnet* of the globe of the Earth, haue a maruelous ſtrong *Magneticall* power imparted vnto them, that they cannot be turned either higher or lower, or moued to the right hand or to the left, but hold the Earth continually in a true and certaine poſition and place, and would if any force or power ſhould moue their great ſtrength awry from the true ſyte and meridian latitude, returne to their right ſyte and place againe, and this is the true vertue of the Poles of globes, which the Sunne and *Iupiter* haue as well as the Earth.

Theſe Poles be moſt certaine and ſure markes for all *Magneticall* bodies, conueniently caried to direct themſelues vnto, *Tab. III. Fig. 9.* as appeareth by our Compaſſes, which in all places of the world turne their Lilly into the North, whereby the Marriner knoweth what courſe to take. And the *Magneticall* Pole, & Poles of the world, both articke & antarticke, are all one and not diuerſe, as ſome haue imagined, which haue loſt both their oyle and their paines; and this is true, by the demonſtrations and motions of the *Inclinatory-needle*, although there be many momentary cauſes of variation.

Theſe Poles hold the Earth certainely in her polar poſition, while ſhe turneth her ſelfe about to receiue the Sun-beames, and influences of the ſtarres and planets, for the generation and maintenance of all inferior bodies, vpon her, in her, & proceeding out of her.

Laſtly, theſe Poles of the Earth, in certaine great number of yeares, haue naturally a little inclination in the polar circles of the Zodiacke, for the receiuing and moderation of the beames, lights, and influences of the ſtarres, whereby the progreſſions and anticipations of the æquinoctiall, and the mutations of the greateſt declination of the Sunne are perfectly vnderſtood, to preuent the faining of many Spheres aboue the ſtarres, as the ninth, tenth and eleuenth, and their impoſſible motions.

In faſhioning the *Loadſtone*, it is conuenient to make flat or roundiſh the ends of the *Magnet*, where the Poles are the better to cap and arme them with iron or ſteele, to lift vp their conuenient waights, *Tab. III. Fig. 2. & 12.* and as the moſt are, *Tab. I.*

At the Pole the *Inclinatory-needle* doth not incline obliquely to the *axis*, *Tab.III. Fig.6.* as the needle *c c* to *a b* the *axis*, as in other places, but aſpecteth the Pole directly and perpendicularly, as *Tab.III. Fig.*1. the needle *c* reſpecteth the *axis b a* directly, & maketh one line with it.

Alſo at the North-pole that point of the directory-needle, and compas, that did behold the South of himſelfe, being applied to the North-pole, doth turne, as ſome thinke, but this is true only at the æquator in the ſpaces between the æquator & the 34 degree, as is demonſtrated in the XII. chap. & not at the Pole it ſelfe, and the places neere adioyning: for at the North-pole, if the *Magnet* be truely placed, that point that pointeth towards the South, doth point to the South directly, and in the places neere adioyning doth it obliquely. A wier touched *Magnetically* hath two Poles, as *Tab.III. Fig.*5. the one end *a* is North, and *b* of the nature of the South.

CHAP. VII.

Of the Axis.

THe *Axis* or axeltree of the *Magnet*, is a line that paſſeth from the one Pole to the other, by the center of the body of the *Loadſtone*, and after this order there is an *Axis* vnderſtood to be in the Earth, *Tab.III. Fig.*1.2.3.& 9.10. In faſhioning of *Magnets*, if a peece be taken away paralell from the *Axis*, then in theſe two *Loadſtones* the *Axis* with his poles will be remoued into the middeſt of the ſtone, as *Tab.III.Fig* 3.*a b*, the *Axis* in either peece is in the middeſt of the ſtone; ſo whether that bunches be taken away from the *Loadſtone*, or any cauities filled, the *Axis* will alwayes be placed in the middeſt of the moſt vigorous bulke of the *Load-ſtone*, as *a b* in euery figure.

It is ſaid in the latter end of the V. chapter, that if a *Loadſtone* be ſawen in two parts, from one pole to the other, vpon the *Axis*, that the poles and *Axis* will be found in the middeſt of the bulkes of the two peeces paralell to the old *Axis*, *Tab.III. Fig*.3. and the poles of the leſſer peece will be altered.

Alſo when as a ſide of the *Load-ſtone* ſhall be made flat and paralell to his *Axis*, that ſide will attract, hold and vnite vnto him long peeces of iron ſidelings and paralelly, *Tab.III.* as *Fig*.4. *c* the peece of iron is adioyned paralelly to *a b* the *Axis*, as the pole erecteth perpendicularly to it, *Tab.III. Fig*.2. the waight *c* is attracted plim-wiſe to the *Axis a b*. And alſo two *Magnets* ſomewhat long, in forme ſwimming in their veſſels vpon the water, wil adhere and vnite in a meridian paralell to their *Axis*, *Tab. XI. Fig*. 5. that if one of their veſſels be haled, the other veſſell with the other *Magnet* his loading will follow, both being faſt grappled together, ſo that they cannot part aſunder.

Likewiſe, take two *Magnets*, that be armed with their teeth of iron or ſteele, deſcending from theſe poles at right angles to the *Axis*, to take vp, with both teeth together, & haue their *Axis* both of one length, as *Tab.III. Fig*.12. place the teeth deſcending from the South-pole, vnto the teeth that haue the vigor frõ the North-pole, and they will cleaue and vnite together as one body and *Load-ſtone* paralell-wiſe to the

Axis, and the one, though he be the weaker, will lift vp the heuier perpendicularly.

Alſo all *Magneticall* bodies, whether it be at the æquator, at the poles, or at any intermediall part, betweene theſe two, do all of them apply, conforme, and vnite their bodies together, according to a correſpondency of their *Axis*, as ſhall be declared hereafter, and not with their center to the center of the others body.

If a wier be touched *Magnetically* at one end, the vigor will run through all the wier, or *Axis*, and haue a contrary vertue in the other end, the one North, the other South, and halfe the *Axis* will be of one nature, and halfe on another, *Tab. III. Fig.* 5. the end of the wier at *a* is of the nature of the North-pole, and the end at *b* is of the South-pole.

We ſayd in the III. chapter, that the Moone doth alwayes turne one Pole of her body toward the center of the Earth, and moueth neerer & further from the ſame, as if that a long axeltree were paſſed through her body, & faſtned in a ioynt to the center of the earth, on which ſhe ſhould make her *Epigeum* and *Peregeum*; in like maner, it is to be probably gathered, that the earth may naturally haue a *Helicall* & *Spirall* vertue to moue on the Cilinder of her *Axis* in *ſpirall* lines, not vnlike the arches of the longitude of the day, to performe the Zodiacall motion, partly illuſtrated in the XXII. chapter by the bead, in an inſtrument of rings for the finding of the variation, where the bead, as an earth, is placed in the *Axis*, higher and lower, according to Zodiacall direction, and *Magneticall* vertue will permit this *ſpirall* motion, like as the ſap paſſeth in the earth from the North hemiſphere, to the South prouince.

It is a thing worthy of better obſeruation from the Truncke-glaſſe, to know whether the *Axis* of *Iupiter* and the Sunne be paralell one to the other, and with the *Axis* of the Earth, which is to be examined by the turning of the ſpots about.

CHAP. VIII.

Of the Æquator.

IN all *Magnetical* bodies there is an *Aequator*, or middle fence, that diuideth the whole body in the middeſt betweene the two Poles, like a middrift, into two equall parts, hemiſpheres, and prouinces: outwardly in the middle part in the greateſt circumference from the poles, there is an *Aequator*, circle, or line, that deuideth the North-part of the ſtone from the South part, as by a border-marke, ſo that if a directory-needle touched *Magnetically*, be conueyed to any part betweene this *Aequator* and the poles, preſently the end of the needle that is of the nature of the other prouince beyond the line of the *Aequator*, will turne about from that part, and the other end of the needle that hath affinity and naturall conformitie with the pole of that prouince, will offer it ſelfe, as *Tab. III. Fig. 6. 7. 9.* 10. in the prouince of the North-pole *a* aboue the *Aequator* and pricked line, the bearded ende of the needle doth only offer it ſelfe, and deſire to apply and vnite to that part, but the croſſe end of the needle wil flye from it; ſo this croſſe end of the needle will only affect to behold the ſouth prouince vnder the *Aequators* pricked line to the pole *b*, and the bearded end of the needle will ſhift away. This aſſertion is not only found to be true in the *Loadſtone*, but alſo in other formes of iron and ſteele, and in the great Earth it ſelfe. As take a round plate of iron that hath laine ſome time quietly without ſtirring, as *Tab. III. Fig. 6.* or a ring of iron, *Tab. III. Fig. 7.* and offer the ſides of this plate, or ring, vnto the needle, turning them about, and the bearded point of the needle will reſpect the one halfe of theſe iron circles, and the croſſe part of the needle, being of the nature of the other ſemicircle, will apply and haue reſpect thereto. Here in theſe iron formes the *Aequator* and limit of the two ſemicircles, is better perceiued where it ſhould be marked, then the poles are: for when the *Magneticall* needle is once paſt the bounds of the *Aequator*, preſently he turneth about his other point that reſpecteth the contrary ſemicircle, or rather hemiſphere, the which for diſtinction ſake might be painted of a red colour.

Moreouer, if a directory-needle, or Marriners compas be placed neere the *Aequator* of a *Loadſtone*, of theſe iron formes, or of the earth, they will ſituate themſelues paralel to the *axis* of the poles, as *Tab. III. Fig. 6. 7.* and *Tab. VI. Fig. 1. Tab. VII. Fig. 1. 2.* and incline neither to one pole, or the other, being placed in a right ſphere, where the poles lie in the Horizon, the needles ſtanding in equall ballance with the Horizon, looking North and South, paralell to the *axis*.

Whereas it hath bene declared in the VI. Chapters before of the vigor of the poles, that the vigor and ſtrength *Magneticall* proceedeth by little and little from the *Aequator* to the poles, increaſing in their paſſage by the meridians vnto the poles, to the end to augment their vertue of retaining, & conſiſting moſt firmely and conſtantly in the North and South, wherby the *Aequator* of the earth is left voide of all vertue of conſiſtence, and left free, or rather depriued of conſtancy and retaining of any firme ſituation, and remaining naturally, by reaſon of his great circumference and weake renitency, moſt apt and prone for circular motion, which by her ſtar-like vigor and intelligence, hauing this her globous body ſo firmely faſtned naturally in her poles, as it were in two ſtrong pillars, and fitted in the *Aequator* and paralels, as in Chariot-wheeles: for circumuolution turneth her ſelfe daily about from the West into the Eaſt, to meet with, and receiue the pleaſant beames and influences of the Sunne, Starres, and Planets; for to cheriſh, comfort, and inuigor all thoſe goodly creatures that be placed vpon her, grow out of her, or be bred and conceiued in her, as alſo for the continuall change and viciſſitude of ſeaſons, being a thing more naturall and fit that the earth ſhould thus moue for her owne good, then that all the heauens ſhould furiouſly moue to ſerue her.

It is to be obſerued in faſhioning of the *Magnet* ſtone, that when the *axis* of the ſame ſhall be cut ſhorter, that then the *Aequator* remoueth neceſſarily to the middeſt of the body of the *Loadſtone*, as if a long *Magnet* ſhould be ſawne and deuided into two peeces, as *Tab II. Fig*. 8. vpon, or paralell to the *Aequator*, the poles will be in the middeſt of the ſtones, and the *Aequator* will alſo be in the middeſt of either ſtone, as *a b*, and the pricked lines be.

For euery peece and part of a *Loadſtone* hath his poles and *Aequator*, with the reſt of the circles, as well, and as naturally as the earth, or any great *Magnet* hath, and will be deuided into two iuriſdictions by his *Aequator* though before all his part was but of one prouince and nature. Euen ſo if you part a needle, or long, wier *Magnetically* touched, in two peeces, the parts will haue their ſeuerall poles, as *Tab. III. Fig.* 5. the poles *a b* are in either part of the wier.

CHAP. IX.

Of the Meridians.

THe Meridians be great circles drawne by the æquator vpon the *Loadſtone*, or as may be obſerued by the needle vpon the face of the Earth, from the one pole to the other, where they do all touch, as in the centers, *Tab. III. Fig. 9.* they be naturally in euery *Loadſtone*, and in the earth, and are thus found out: for they be the pathes whereon all *Magneticall* motions are trauerſed and directed. Lay a wier of a reaſonable length vpon the *Magnet*, as *Fig. 9. a b*, and it will turne and ſeate it ſelfe vpon a Meridian, and point to the poles, and if he be moued from the Meridian by any force, he will ſoone returne to the ſame againe, and by this wier you may marke out a Meridian; Likewiſe take a little directory-needle of a ſmall diall, and ſet it vpon a ſmall pinne with a foote, ſetting them vpon the *Terrella, Semiterrella*, or any *Mignet*, *Tab. III. Fig. 9.* and the needle will point towards the pole, make a marke, remouing the needle forward, and make more, then ioyne all the points together, which make a part of a Meridian, and being continued forward runne to the pole, ſo a ſmall and ſhort wier placed vpon the *Magnet* from place to place betweene the æquator, and the pole, will ſticke faſt at one end, and erect the other obliquely, and the ſeuerall places, being noted with chalke or emery, will ſet out a Meridian to the pole, at the æquator, being no longer then a barley corne, will lie flat to the ſtone, put him forwards toward the pole, and then he will erect himſelfe a little, ſticking at the other end vpon your *Terrella*, *Semiterrella*, or *Magnet*, put him more forward, and he will be erected leſſe acutely, and about 34 degrees from the æquator, he will make a right angle with the *axis* of the *Magnet*, and being brought and placed vpon the pole, ſtandeth vpright in one continued *axis*, with the *axis* of the *Loadſtone*, *Tab. III. Fig.9.* This variety of application to the *Magnet*, doth produce a certaine kind of motion *Magneticall*, which may be called the motion of inclination, conuerſion, or conformity of one *Magneticall* body vnto another; but the little directory-needle demonſtrateth this motion beſt, being caried about the *Terrella* and *Semiterrella*, as ſhall be demonſtrated in the XII. Chapter following.

I haue ſpoken before ſomewhat as concerning the making flat of a ſide of the *Loadſtone*, paralell to the *axis*, which is a Meridian line paralell thereto, whereby waight may be apprehended, *Tab. III. Fig.4.*

Therefore hauing a *Magnet* ſtone firſt made flat at the ends, where the poles are, and after a ſide made plaine and ſtraight, paralell to the *axis* for a Meridian, then you may forme the ſtone into what faſhion you pleaſe, as into a foure-ſquare, into a figure of 5, 6, or 8 equall angles or ſides, or into vnequall ſides, as hath bene ſhewed in the firſt Table in many types.

Cut a part from a *Magnet* ſtone meridionally, and that end which was placed South when it was whole, being ſeuered, will turne North, though naturally at firſt it was the South point, as in *Tab.III. Fig.3.* the poles *a b* in the little peece are turned contrary to the poles *a b* in the greater *Magnet*.

CHAP. X.

Of the Paralels.

THe Paralels be circles and parts equidiſtant from the pole, and Paralell to the æquator, and do poſſeſſe the whole ſpace betweene the æquator and the pole, as *Tab.III.Fig.*10. theſe circles are pricked out, as the æquator is, and are found by the *Inclinatory-needle*, being caried at one angle about the *Terrella*, and in all theſe places the ſmall wiers, *Tab.III.Fig.9.* and directory-needles, *Tab.III.Fig.*10 do apply their *axis* or line of length obliquely to the *axis* of the body of the *Magnet a b*, or of the earth.

For to find out theſe oblique angles in euery Paralel, and what correſpondency they haue vnto them, there be diuerſe operations, diagrammes, inſtruments, and calculations found out to demonſtrate, and to know what angle of inclination will anſwer to euery Paralell: for in euery Paralell of the earth the *Inclinatory-*

needle maketh a diuerſe angle of inclination to the *axis*, but one angle, and of one ſort, in one and the ſame eleuation of the pole or Paralell, and by this meanes of the *Inclinatory-needle* in a ring, the latitude of the pole is knowne on both ſides of the æquinoctiall, without any ſight of the Sunne and ſtarres, by the *Magneticall* diſpoſition from the earth.

If in forming of the *Loadſtone*, ſome Paralels be cut away, as it ſhould ſeeme in the *Terrella*, by cutting and flatting the end where the pole is, *Tab. III. Fig.* 11. yet in truth they remaine ſtill vpon the *Magnet*, though the Meridian lines be changed from crooked lines to ſtraight lines, and this is to be obſerued, that alwayes the Paralell neere 34 degrees in the perfect *Terrella*, *Semiterrella*, and round Meridian, or ſtraight Meridian, where the directory-needle aſpecteth, that edge, or angle, at right angles, vnto the *axis*, *Tab. III. Fig.* 11. and *Tab. VII. Fig.* 2. as the moſt protuberant and middle place betweene the pole and the æquator, as in this *Load-ſtone* truncated and flatted at the pole.

In the Paralels of like diſtance from the pole, all *Magneticall* bodies do apply and conforme alike, and haue the like inclinations of their *axis*, that denotate like eleuations of the pole, and do attract and retaine with like forces and vertue, *Tab. III. Fig.* 11.

Place two wiers vpon a Paralell of the ſtone, as you would ſay Eaſt and Weſt, and they will not conioyne or vnite together, *Tab. III. Fig.* 11.

Rub the needle of a dyall Paralell-wiſe on the *Loadſtone*, and it will hardly be excited and animated, vnleſſe the touching be neerer vnto the pole.

CHAP. XI.

Of the Horizon.

THe *Aequator*, the *Meridians*, the *Paralels*, the *Poles* and *Axis*, are all naturally in the Globe of the Earth, and in euery *Magneticall* body, and not imaginary in the heauens, as Aſtronomers heretofore haue thought, not knowing in what body to find them naturally. Now it remaineth to write of the Horizon, which is a great circle that deuideth the Globe of the Earth into two hemiſpheres, or into two equall parts, like as the æquator doth deuide the *Magnet* into two prouinces, and though that the Horizon be of great vſe in *Magneticall* practiſes; yet I cannot affirme that the Horizon is naturally in the Earth, or any other *Magneticall* body, as the æquator is, onely euery point and place vpon any meridian and paralell may be the center of the Horizontall circle, which center is *Magneticall*, and of many vſes in *Magneticall* demonſtrations, both to know on what paralell and eleuation of the pole, aboue the Horizon the inclination and conformation of the *Inclinatory-needle* is obſerued, whereby we come to the knowledge of the angle that inclinatory maketh with the Horizon, in euery paralell of the earth, and by a reſpondency that it hath with the *axis* of the eleuation of the pole we come to know, as hath beene ſayd, the latitude of the pole in all places of the world, without the vſuall helpe of the celeſtiall bodies, hauing as

certaine

certaine an helpe from the materials of the Globe of the Earth, and their vigor for this concluſion, as from any other globe whatſoeuer.

This center of the Horizon alſo is the place whereon the Pilot placeth his Compas, and compoſeth the ſame leuelly and parallelly to the circle of the Horizon, ſo that by the firme direction of the Lilly of the Compas to the North, he knoweth which way to ſteere his ſhip to the deſired port.

The Horizon therefore of vſe is a plaine and parallell ſuperficies vnto the horizontall circle it ſelfe, and is to be deuided into 360 parts, from which lines are to be drawne to the center of this horizontall circle, and may be called the lines of poſition, verticals, and Azimuth, whereof one of them is of principall note, and is called the *Magneticall* meridian line, from whence the reſt are to be numbred, and by which we are helped to knowe the declination of the Marriners Compas from the true meridian of the world, which thing is commonly called the variation of the Compas. For although that naturally the directory and *Magneticall* needle, or Compas, ſhould place it ſelfe vpon the true meridian, by the diſponent vertue of the *Magneticall* globe of the Earth, yet by reaſon of the neighbour-hood and approching of other eminent, forcible, and great *Magneticall* continents, this needle is turned awry from the true meridian and varieth, and declineth to the one ſide or the other, certaine parts and degrees to be reckoned vpon the horizontall circle.

Whereas it is ſayd by ſome, that the horizontall circles make alwayes right angles with the *axis* of the earth, this aſſertion cannot alwayes be true, but this circle of the Horizon maketh alwayes a right angle with the meridian, whereon he ſtandeth.

CHAP. XII.

Of the two circles that the Needle maketh about the Magnet.

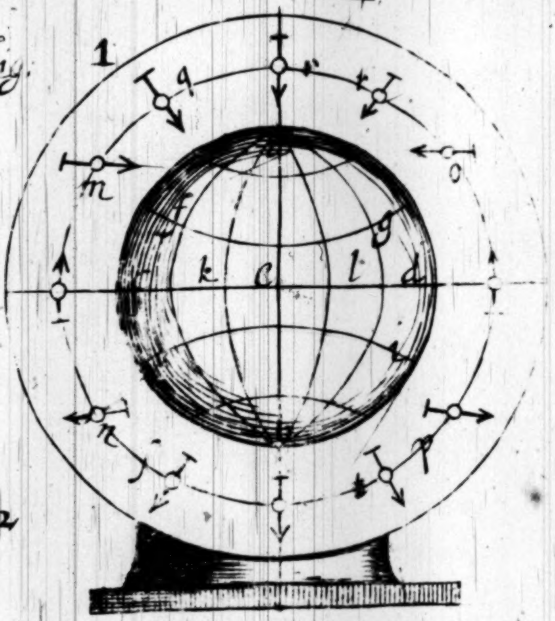
HAuing explained before the nature of the poles, the *axis*, and the circles, and parts of the *Magnet* to be naturally in the ſame, and in the globe of the earth; Now it followeth that we demonſtrate how the *Magneticall* needles and wiers doe conforme themſelues to the meridian of the round *Magnet*, whether it be a *Terrella* or *Semiterrella*.

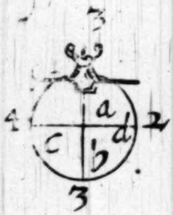
For this purpoſe it is very neceſſary to haue theſe formes truly rounded, to be caried artificially vpon a foote, and fitted within the head of the ſame, in a circular and hollow cauitie, that may receiue the ſtone, ſo that the two poles of the *Magnet* do lye leuell with the Horizon, leauing a thin ring of the foote about the ſtone, vnder which there is a ſhoulder, a quarter of an inch thicke, left of the abatement of the height of the foote round about, to beare a round verge or limbe of paſt-boord, braſſe, or ſiluer, for a meridian or right horizontall circle, as is vſed to be done in the placing of all globes in their frame or foote, whereon may be made diuerſe ſituations of needles, and deſcriptions *Magneticall*, as *Tab.IIII.Fig.*1.

In the firſt figure *a b c d e*, is the round *Magnet*, *a* the

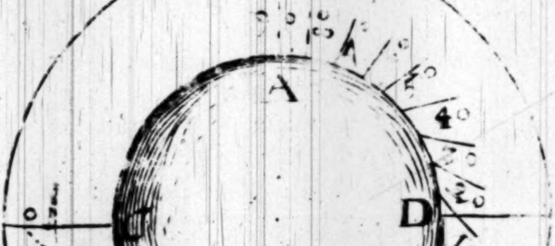
Tab: IIII

fig. 1





f. 2



North-pole, *b* the South-pole, *a e b* the *axis*, *c e d* the æquator, *a k b* and *a l b* the meridian circles, meeting at the poles, and *a c*, and *b d* the meridian, or right horizon, hauing the poles in it, *f g* and *h i* be two paralels. The *Magnet* being thus adorned outwardly, as it is indowed inwardly, after place the needles, being before touched, on the limbe ouer againſt the poles *a b*, and they do aſpect the ſame directly, making one ſtraight line with the *axis* of the *Magnet*, then ſet needles in the verge againſt the æquator *c d*, and they will carry themſelues in a paralell ſyte to the *axis* of the ſtone, and looke neither to the one pole nor the other: ſo that hereby you may gather that there is a ſemicircle betweene euery one of theſe 4 needles. Now to find out the quadrants of theſe ſemicircles, apply needles in the limbe at *m n o* and *p*, which letters be about 33. *deg.* 58.′. 13.″. diſtant from the æquator, on each ſide on him, and they will be ſituated at right angles with the *axis* of the ſtone, where theſe eight needles haue eight quadrants betweene them that is 4 ſemicircles, which make two whole circles, one on each ſide of the æquator: for the reaſon hereof I will giue you a conceit at the latter end of this booke. And if you place needles in the middeſt, betweene the æquator and the poles, as in *q r ſ t*, they will behold the æquator, but will reſpect the *axis* obliquely, as in all other places and parts, except in the eight places before mentioned.

The better to vnderſtand this foreſaid demonſtration, I would wiſh you to haue in readineſſe a little directory-needle, with a foote flat and round, and a pinne in the center of it, to carry the needle, as in the third type of this IIII. Table. Let this circular foote be deuided into foure parts and quadrants, with lines croſſing each other at right angles in the center *o*, where the pin that carieth the needles, and at the beginning of euery quadrant ſet theſe figures, at the firſt 1, at the ſecond 2, the third 3, and the fourth 4, now in the limbe, free from all needles, ſet downe this needle with his foote at the æquator *d*, and the needle will ſeate it ſelfe paralell to the *axis* of the *Magnet a b*, then turne the foote of the needle about, that the diamiter of the figures 1, 3, may be directly vnder the needle, thus in this ſyte carry the foote and this diamiter of the needle alwayes paralell to the *axis* of the *Magnet*, and place it in *m*, where it will point ouer the figure 2, the beginning of the ſecond quadrant hauing finiſhed one quadrant of circumuolution about the foote or epicicle, then carry this foot with the needle with this diamiter paralell to the *axis*, as before, and place it againſt *a* the pole, and the needle will point to 3 the figure of the foote: hauing finiſhed halfe the epicicle of his foote, then remoue the foote with the diamiter 1, 3, paralell to the *axis* of the *Magnet*, and reſt it at *o* in the rimme, and the needle will point at 4, hauing perambulated three quadrants, and then reſt him at the æquator *c*, where he will point to the figure of 1, againe, hauing finiſhed a whole epicicle about his foote, in this iourney about halfe the *Magnet*: ſo likewiſe if the needle be tranſported beyond the æquator to trauell by the other pole *b*, to finiſh another epicicle, the point of the needle, that is of affinity with this iuriſdiction, will offer his ſeruice, whereto place the figure of 1, to ſtand iuſt vnder him at the æquator *c*, which here likewiſe will be ſituated paralell to the *axis* of the *Magnet*, and the foote being in this ſort æquidiſtant-wiſe to the *axis* conueyed in the limbe to *p*, the pole *b* to *n*, and laſtly to the æquator *d*. againe the needle in this hemiſphericall part of the body of the *Magnet* will deſcribe another epicicle about the foot that carieth him, ſo that it is moſt apparent that the needle in his circũambulation about the *Magnet*, doth turne himſelfe twiſe about, and make two whole circles, or epicicles in this voyage, as hath bene demonſtrated.

Whereas the needle in his progreſſe from *d* the æquator to *m* is but almoſt 34 degrees from the ſame, in which ſpace he maketh his firſt quadrant, but the way from *m* to the pole *a*, is almoſt twiſe as large, in which he maketh another quadrant, it is neceſſary that this circumuolution of the needle from the æquator *d* to *m* not 34 degrees, ſhould be much more ſudden and ſwift, being in ſo little a ſpace of the quadrant *d a*, then that forming of a quadrant by the needle vpon the epicicle of his foote when he paſſeth from *m* to the pole *a*, being a ſpace almoſt as large againe, and therefore the mouing of the needle in making the ſecond quadrant of his foote, ſhould be almoſt twiſe as ſlow as the finiſhing of the firſt quadrant, if like time be allotted to both their paſſages. I thought good to ſet this needle and foote in the III. figure, vpon the limbe in the next *Tab. V.* which will ſerue alſo for the demonſtration in the chapter following.

Yet it may be noted to the contrary hereof, the caſe being altered, that if there were a cutting away made of part of the paralels about the pole, and that the pole were made flat and plaine, as it hath bene ſhewed *Tab. III. Fig.* 11. that then the application of the needle at right angles, to the *axis*, at the angle and edge of the *Magnet*, being the moſt protuberant place, and the needle would deſcribe but one quadrant from the æquator to this angle, and the other quadrant of the needles conuerſion, betweene this angle and the pole, would be on the flatted end; and then in this truncated body, the motion from the æquator to the angle, for the firſt quadrant would be very ſlow, and the motion for the ſecond quadrant would proue far ſwifter.

Now for *Magneticall* attraction and apprehenſion, it is to be obſerued, that at the poles the *Loadſtone* doth attract and retaine *Magneticall* bodies perpendicularly and moſt ſtrongly, and at other places moſt weakly and obliquely, and neerer the pole more ſtrongly. But where the poles be flatted, as is ſayd, and the application at right angles, there the erection of waights is altogether as ſtrong as at the poles, taking vp in parallell-ſort vnto the *axis* of the *Load-ſtone* by two teeth, and at right angles by one tooth.

Laſtly, for the vſe of the application of the *Inclinatory-needle*, I haue ſet downe a ſecond figure, and in the margent haue delineated out in pricked lines, what application the needle hath, and maketh in euery tenth degree of the quadrant, from the æquator to the pole in the limbe of the quadrant *C B*, as likewiſe in the quadrant *D A*, there is ſet forth how the ſmall wier and ſhort erecteth it ſelfe in euery tenth degree in that quadrant, a thing hereafter more plainely demonſtrated by a diagramme in the XXXVI. chapter, by calculation, and by ring, but indeed the matter will be more naturally and truely demonſtrated in the chapter following.

CHAP.

CHAP. XIII.

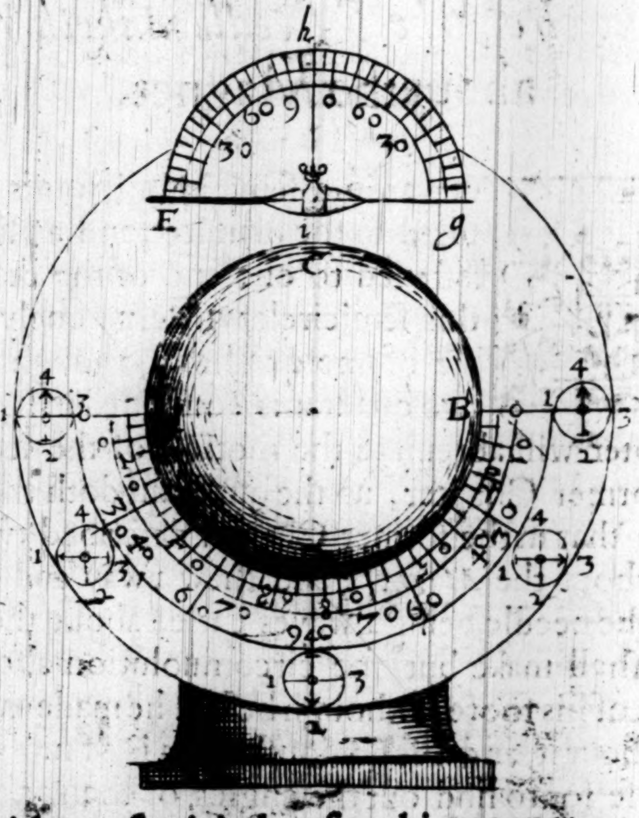
Of one circle the Needle maketh round about the Magnet.

Euc.3.Prop.

EVen as in a ſemicircle if ſights be applied to the diamiter, and a plim line faſtened to one end of the diamiter, this ſemicircle will ſerue onely for the vſe of one quadrant, though it haue two quadrants contained in it, ſo this Chapter will abreuiate the motion of the needle in the former Chapter, as the quadrant doth the ſemicircle that in the former Chapter deſcribed two circles about the *Magnet*, and ſhew a way and deuice how the needle, being alwayes caried about the *Magnet*, ſhall make but one circomuolution about the circle of his foote, although before he made two circles about it, and this demonſtration is of moſt neceſſary vſe for to find out the angles of the *Inclinatory-needle*, with the *axis* of the Earth in euery eleuation of the pole, and what they are from the Horizon, and knowing what number of degrees they include in any place, the altitude of the pole in the ſame place ſhall be accordingly knowne.

It is conuenient for the performing of this demonſtration, to haue a verge and limbe for the ſayd *Leadſtone* mounted vpon his carriage, as before, ſomewhat looſe, not fixed, that it may the more fitly be moued and turned about the *Magnet*, I would it were furniſhed

Tab. V



ſhed with two ſemicircles after this manner.

In the *Terrella* or *Semiterrella* let the poles be *A* for the North, and *B* for the South, and the æquator *C D*, part the ſemicircle *A D B* into two quadrants at *D*, then make other ſemicircles in the verge without *A D B* for the degrees and figures in each quadrant, as is vſed to be done in other quadrants, then deuide each quadrant, and euery one of theſe into three other parts, then deuide theſe parts into ſmaller parts, and if the circle be bigge inough, deuide theſe laſt into fiue parts a peece, and thus haue you either quadrant deuided into ninety parts, then ſet the vſuall numbers of tens at euery tenth part to ninety, ending at *D*, as in this type, *Tab.V. Fig.*1.

Then about a quarter of an inch aboue *c* in the verge, draw a line at 1, at right angles to *C D*, and from 1 as a center deſcribe vpward a ſemicircle to touch that line *F* 1 *G*, deuide this ſemicircle into two parts and quadrants at *H*, ioyning 1 *H* together in one line, after draw other ſemicircles within the ſemicircle *F H G* for the degrees and other numbers, as you did in the former quadrants, then diuide each of theſe quadrants into 90 parts, beginning the diuiſions at *F G*, and ending at 90 in *H*, then ſet the figures at euery tenth degree, as is vſed to be done. Laſtly, vpon this center 1, place the *Magneticall needle* vpon his pin, *Tab.II. Fig.* 20, that is, the needle that is thicke and ſhort, hauing at the one end an hole drilled, for to receiue a wier of braſſe or ſiluer, to counterpoyſe the thicke head of the needle, and to reach vnto the fartheſt circle of the deuiſions of the two quadrants of this ſemicircle: this needle and ſemicircle would be couered with ſome glaſſe and ſlude, as dials vſe to be couered, for a little aire and the breath of your mouth, when you looke neere to ſee what deuiſions the taile of the needle cutteth, will moue the needle and driue it away.

This limbe and verge thus furniſhed with theſe two ſemicircles, and this needle being placed about the *Terrella* or *Semiterrella*, ſo as it may very eaſily without any great force be turned about; in this ſituation of the needle, as it is in the type, the needle ſeeth it ſelfe at the æquator *C*, paralell to the *axis* of the ſtone *A B*; we will call the inner ſemicircle of the limbe *A D B*, that is next to the *Terrella* or *Semiterrella*, the meridian circle of the altitude of the pole; the outward externall ſemicircle *FHG*, we will terme the meridian Inclinatory ſemicircle, becauſe the needle Inclinatory doth ſhew in theſe quadrants certaine parts and degrees, anſwerable to euery degree of the eleuation of the pole, of the *Terrella*, or *Semiterrella*, declared in the inner quadrants of altitudes of the pole.

For practiſe hereof, if it be deſired to know where the pole is eleuated ten degrees aboue the Horizon, what degrees the *Inclinatory-needle* will point at in the Inclinatory meridian ſemicircle anſwerable thereunto. Here turne about the limbe and verge, vntill ten degrees of the ſemicircle of altitude be placed iuſt with the pole *A*, the pole being eleuated ſo many degrees aboue the Horizon, then looke in the quadrant of the meridian inclinatory ſemicircle, and his needle will point to 20 degrees, the very true parts, the *Inclinatory-needle* being placed in his ring and meridian circle, hereafter to be deſcribed, will point at in trauelling where the pole is eleuated ten degrees, after this manner ſeeke out what will be correſpondent where the latitude of the pole ſhall be 20 or 30 degrees, and this needle will point out the correſpondent degrees of the angle of inclination in the meridian-inclinatory ſemicircle, to theſe or any eleuatiō that ſhalbe deſired.

Therefore here you ſee how profitable, and of what great vſe this demonſtration is, in helping to attaine to the reaſon & true knowledge of the *Inclinatory-needle*, which placed in his ring, and caried about the earth in the meridian, doth only ſhew his angle and inclination to the *axis*, but this demonſtration directeth from the ſtone it ſelfe what will be the number of degrees that the angle of the inclination maketh aboue the horizon, and what degree of the eleuation of the pole wil be anſwerable thereto, and from hence Tables may be made and collected what degrees of the *Inclinatory-needle* wilbe anſwerable to euery eleuation of the pole.

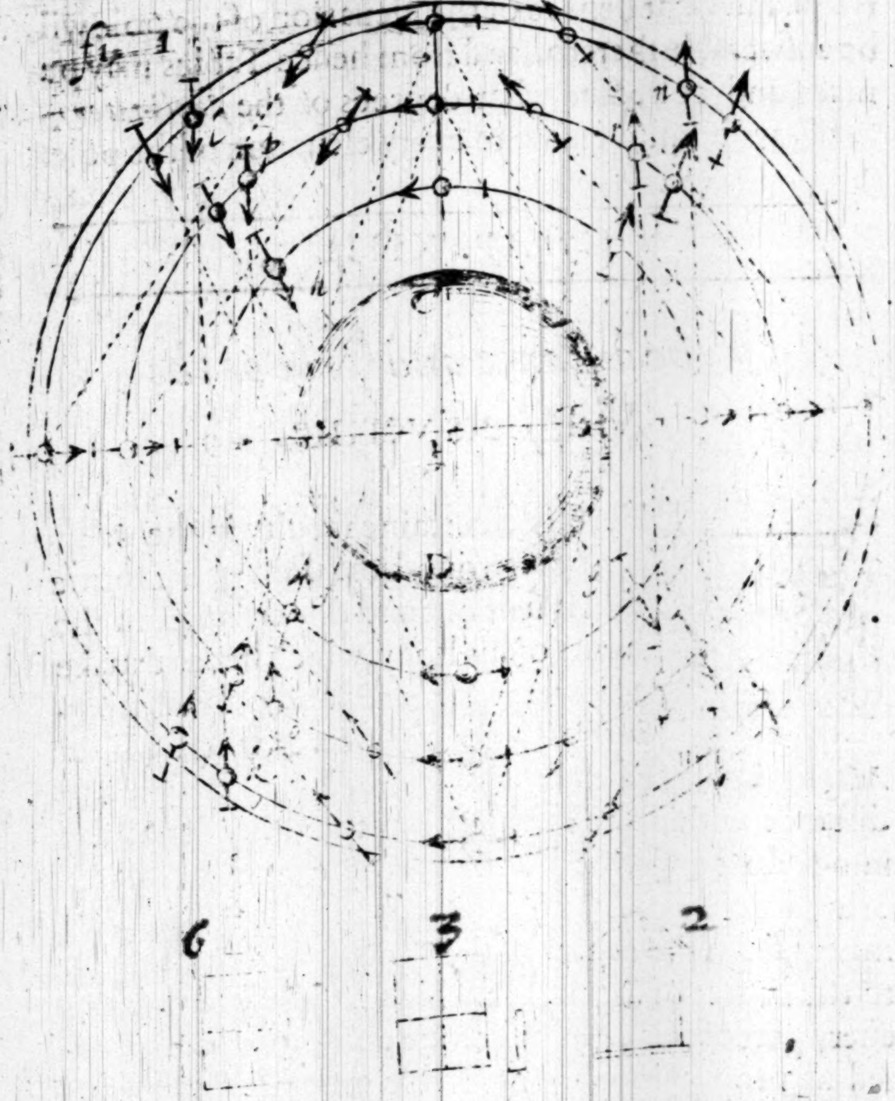
CHAP. XIIII.

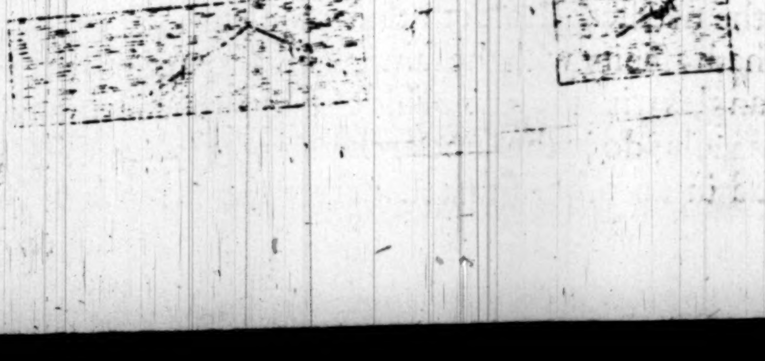
Of the diſtance and Orbe of the Magnets vertue.

THere is a certaine faculty in the *Magnet*, being round, or of any other forme that is ſent out and diſperſed from the limits of his body, which be, and make as it were a ſpheare, and orbe of *Magneticall* vigor and power, where within *Magneticall* needles and bodies being placed in any diſtance within the farthieſt limit and border of the ſame, do conforme themſelues in that place of the orbe, according to a circumference of their ſemidiamiters, from the center of the *Terrella* or *Semiterrella*, to the center of the needle, which needle is alwayes in euery part of this circumference, conformed and ſituated as proportionably as if this orbe of *Magneticall* vigor from the *Loadſtone* were a materiall *Magnet*, and the needle beholdeth that pole with his point that hath affinity with the ſame, and alſo maketh the ſame angles with the *axis* of his circumference, which other needles do in the ſame arches & places, whether they be in an orbe ſituated neerer the *Terrella* or *Semiterrella*,

Tab: VI

fi. 1





terrella, or further off, ſo that the conformities of theſe *Magneticall* bodies are not ſo faſhioned as if the *Loadſtones* and Adamants drew and attracted all *Magneticall* bodies to be ſituated according to the meaſure of his owne ſmall *axis*. But in theſe orbes *Magneticall* needles are moued, incited, diſpoſed, and conformed in all correſpondency, as if theſe orbes were materiall ſpheres. For the ſetting to view of this demonſtration, it is conuenient to haue a large limbe and verge about the *Terrella* & *Semiterrella*, as in this type, *Tab. VI. Fig.* 1. deſcribe the letters about the *Terrella* or *Semiterrella*, *A B* the two poles, and *C D* the æquator, from the center *E* make three circles, or more, in the limbe or verge, at an indifferent diſtance one from the other, for the diſtinction of theſe orbes, within the vigor of the *Magnet*, then at theſe orbes where they croſſe the *axis* and æquator produced, place certaine *Magneticall* needles, which being placed vpon the *axis* will preſently all of them make one line with the ſame, and ſuch as be ſet at the orbes of the æquator, will ſettle themſelues paralell to the *axis*, & at right angles to the æquator. But theſe peraduenture thus placed, do not demonſtrate the orbes ſo well as I would, which therefore I ſhall ſet downe needles in the middle places betweene theſe two diamiters, and all theſe will behold the center where the æquator-line croſſeth their owne orbe, and be paralell one vnto the other, as you may ſee in this Table, *Tab. VI. Fig.* 1. I haue ſet foure wiers *F G H I* vpon the body of the *Loadſtone*, and theſe do erect themſelues in this outward ſuperficies of the ſtone in ſuch order that a line drawne from them, doth directly behold the æquator *C D* of the *Magnet* it ſelfe. Alſo to demonſtrate this demonſtration to your ſence the better, I haue ſet downe in two orbes needles at *K L M N o P q r* at about 34 degrees from the æquator, where theſe do in theſe orbes ſeate themſelues at right angles to the *axis*, and paralell vnto the æquator, beholding one the other in the ſame orbe and prouince in a right line, as if euery orbe were a ſollide *Magnet*. So likewiſe ſuch needles as be placed in the middeſt of the quadrants in the orbes behold the æquator of their proper orbe, as others placed aboue the æquator behold the pole of their orbe.

Place wiers, about an inch in length, within their length in the orbe of a good *Magnet*, and they will skip vnto the *Magnet*, as though they were quicke, and will vnite and adhere faſt vnto it, vntill they be taken off.

The celerity of motions, attractions, and conformities within the *Magneticall* orbe is according to the goodneſſe of the *Loadſtone*, the greatneſſe of his bulke, conueniency of his figure and ſmoothneſſe, and in the ſhortneſſe of the diſtance in the aire, or in water; yet further then in theſe the *Loadſtone* extendeth his vertue by contaction and continuation in a long wier ſet vnto his pole, which wier will moue a needle, or adhere to another wier at the end of his length; but this is done by augmentation of the *Loadſtones* vigor, as ſhall be declared.

Although that ſuch ſubſtances, which be not *Magneticall*, be placed betweene the needle and *Loadſtone*, yet they cannot hinder the orbe and proceeding of the *Magneticall* vigor, as if a *Loadſtone* ſhould be incloſed in a boxe of wood, ſtone, tinne, ſiluer, or braſſe, yet the *Loadſtone* will extend his *Magneticall* orbe, wherein many pretty and ingenious *Magneticall* practiſes may be wrought admirable to behold, as hauing the formes and protractors of creeping things, beaſts, footmen, horſemen, and flies drawne in paſt-boord, hauing but a ſhort wier cloſely conueyed into them, and placed vpon a trencher, paper, or plate, ſhall be cauſed to moue, ſtirre, paſſe on, and flicker, as though they were aliue, onely by mouing the pole of a good *Magnet* directly vnder them.

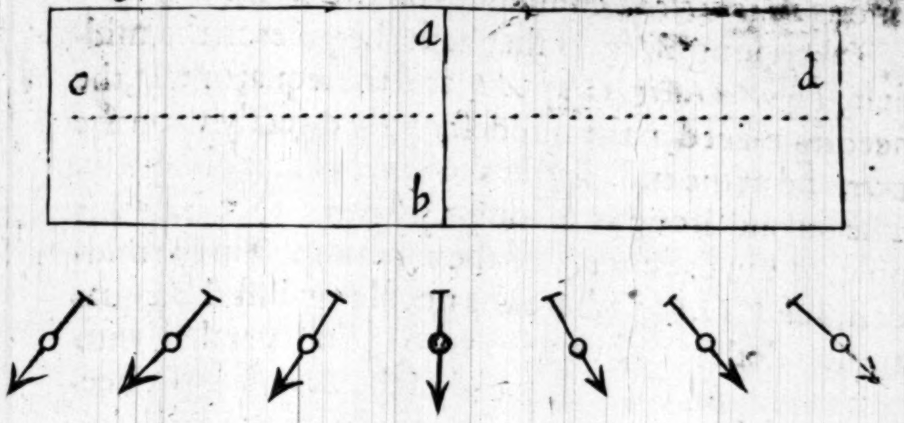
Alſo if a *Magnet* be faſtened in the roofe, or ouer a doore, it will hold an iron waight in the aire, *Tab. VI. Fig.* 2. that hath a thred faſtened to it to hold it ſhort that it be not drawne cloſe for to be vnited vnto the *Load-ſtone*.

Likewiſe if a ſhort peece of iron, or cap, be held within an inch of a ſtrong *Magnet* ſtone, *Tab. VI. Fi.* 3. it will take vp great waights in this orbe, though not ſo much, as if it touched the ſtone and pole: but if the cap be held ouer the pole, it will hold a waight vp rather then the pole, *Tab. VI. Fig.* 6. I hold it needleſſe to demonſtrate how all the needles of dials, *Magneticall* inſtruments, the Marriners compas, and inclinatory-ring do all of them moue within the orbe of the *Magneticall* vigor of the earth, onely I will ſhew you a pretty practiſe or two for delight. Get a wier of foure or fiue inches in length, and thruſt it through a corke, then it being touched with the *Loadſtone*, place it in a baſen of water, and it will moue and direct it ſelfe North and South, by the vigorous orbe of the earth, *Tab. VI. Fig.* 4. and alſo incline and conforme a conuenient angle with the Horizon and *axis* of the earth. This practiſe is profitable for trauellers, who hauing ſowing needles touched, may pricke them vpon any peece of wood, and place them in the water, and it will ſet out the North and South inſteed of a compaſſe: but if for pleaſure-ſake you take another wier, thruſt through a round corke, and let his vpper end be touched at the contrary pole, and placed in the baſon of water, theſe two after ſome time will take knowledge of each other, and will begin to moue and ſtirre, and draw neerer and neerer together, *Tab. VI. Fig.* 5. and comming neere, will moue the faſter, and ſuddenly ioyne together at the vpper ends, on theſe wiers paper-tilters on horſ-backe might be faſtened, and they would runne their courſe together vpon corkes in the water, &c.

CHAP. XV.

Of Applications.

I Haue demonſtrated in the three former Chapters the conformities and applications that *Magneticall* wiers and needles haue vnto the meridian of the round *Terrella* & *Semiterrella*, which may be appropriated vnto the great *Magneticall* globe of the earth it ſelfe. Now in this chapter we are to propound vnto your view certaine practiſes *Magneticall*, and applications vnto long *Magnets*, and formes, that haue the poles in the ends, or in the middeſt where the needles do vary and alter, as they ſhall be applied vnto them ſeuerally, or betweene two of them that haue the poles in the ends, or elſe in the middeſt, which peraduenture may be of ſome vſe in ſailing or trauelling amongſt ſome mounfi 1 Tab VII



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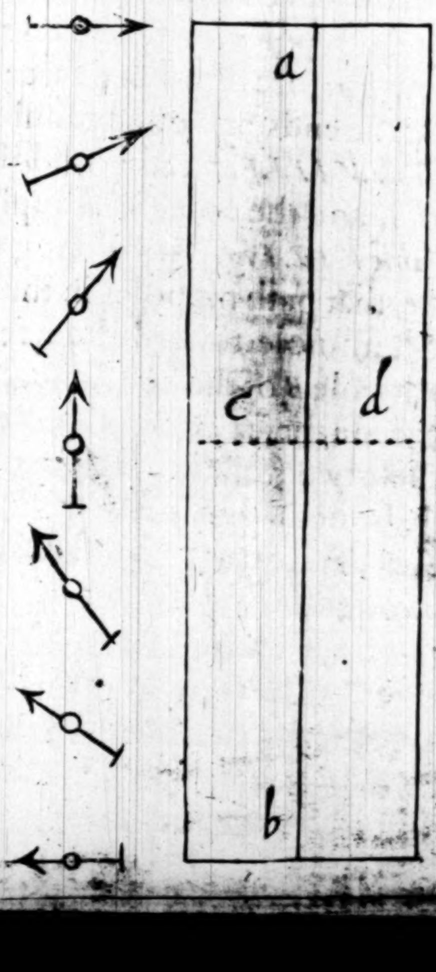

tenous *Magneticall* eminences on the earth.

Take a long *Magnet* that hath the poles in the middeſt, *Tab.VII.Fig.*1. as *A B* and the æquator *C D*, the needles placed in the middeſt, apply directly vpon the *axis*, and at the ends, and at the other places obliquely. The ſecond ſtone is a long *Magnet*, that hath his poles *A B* in the ends, and the æquator *C D* in the middeſt, *Tab.VII.Fig.*2. here the needle againſt the æquator ſtandeth at right angles vnto it, and paralell vnto the *axis*, but at the either end of the *Loadſtone* the needles apply themſelues at right angles to the *axis*, and paralell to the æquator, and in the intermiddle ſpaces the needles apply obliquely to the *Magnet*.

Now I would haue you to prouide two long *Loadſtones*, that haue the poles in the middeſt, like that *Tab.VII.Fi.*1. and before him place three *Magneticall* needles, two at the ends, and one againſt the middeſt, or pole, as in *Tab.VIII.Fig.*1. the middle needle will behold the pole, and the other will apply obliquely, as before in *Table VII. Fig.*1. now bring neere the ſecond *Loadſtone*, that hath his poles in the middeſt, and place *B* the South-pole toward the needles that behold the South-pole *B* of the firſt ſtone, and theſe needles will, betweene theſe two South-poles, reſpect neither pole of theſe two ſtones, but ſeate themſelues paralell to both ſtones, and make right angles with theſe two poles of one nature, as *Tab.VIII.Fig.*1.

Now take away one of theſe ſtones, and after turne the North-pole *A*, towards the needles that behold the South-pole *B* of the other ſtone, and they will all of them ſituate themſelues equidiſtant-wiſe, and at right angles to the æquators of both ſtones, as *Table VIII. Fig.*2.

More-

Tab: VIII

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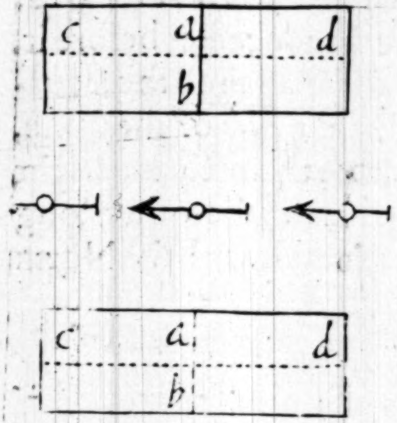

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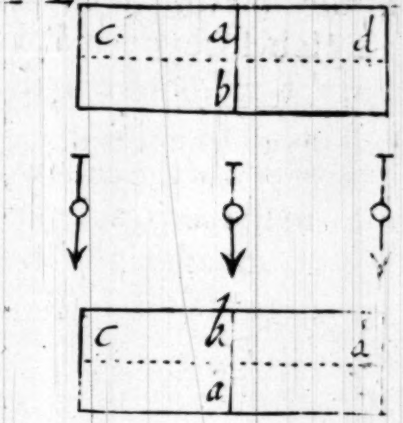

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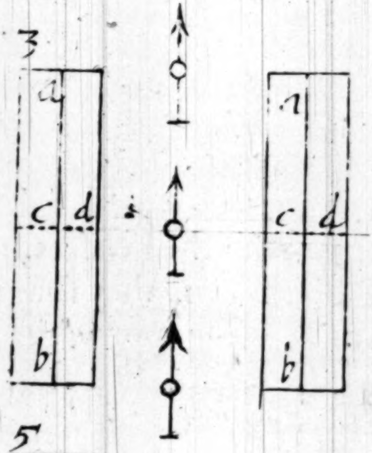

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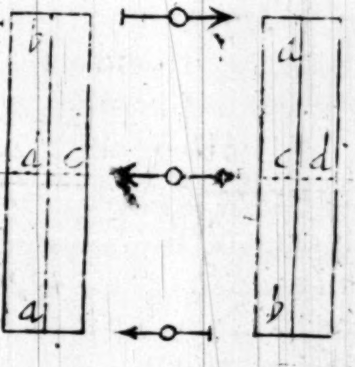

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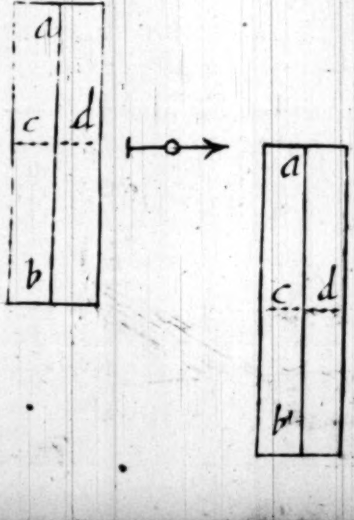

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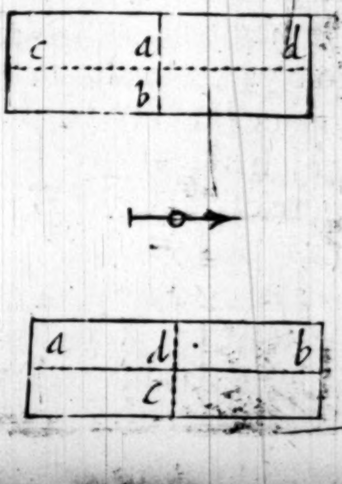


Moreouer, take other two *Magnets* that are long, with the poles in the ends, like that *Tab.VII.Fig.* 2. and lay it before you, and place three needles before it, two at the end, & one in the midſt againſt the æquator, which will apply paralell to the *axis* of the ſtone, and thoſe two at the ends will ſeate themſelues at right angles to the *axis*, as before; then ſet the other long *Magnet* that hath his poles in the ends with the North pole *A*, againſt the North-pole *A* of the firſt ſtone, *Tab.VIII. Fig.*3. and all the three needles will apply themſelues in a ſtraight line paralell to the *axis*, ſomewhat like the order of the firſt type, yet contrariwiſe.

Now take away this ſecond ſtone, with the poles in the ends, & turne it, and place the South end *B*, againſt the North end *A*, as *Tab.VIII. Fig.*4. and then the 3 needles will ſtand at right angles to the *axis*, and paralell one vnto another, and to the æquator.

This is to be obſerued in theſe applications, that the neerer the ſecond *Loadſtone* is placed to the needles, in aſpect with the firſt *Magnet*, the better will they ſhape out theſe figures of applications, & in the approching they will vary, by little and little, from their firſt ſituation, vntill the vertue of the two *Loadſtones* be equall in their orbe.

It may be imagined that theſe applications, for the moſt part, ſhould be found naturally vpon the earth in trauelling or nauigating betweene two great Ilands or high *Magneticall* continents, but the firſt & fourth figure of this eighth Table cannot be found naturally in any place, *Tab.VIII.Fig.*1. and *Fig.*4.

There is alſo much variety of variation in one needle neere two *Magnets*, or a *Magnet* and *Magneticall* body, as place a needle on a little foote vpon the *Terrella*,

rella, Semiterrella, or *Loadſtone*, and it will direct it ſelfe rightly vpon the meridian of the ſtone, as hath bene proued before, *Tab.III. Fig.9.* but if you hold a little peece of iron toward the point of the needle, the point will flie from the iron, and deflect from his meridian a little. Yet let this peece of iron touch the *Load-ſtone* and be vnited vnto it, and put it towards the needle a farre off, and the needle will turne from his meridian, and decline and vary towards it, the contrary is to be ſayd, if this iron be put towards the taile of the needle.

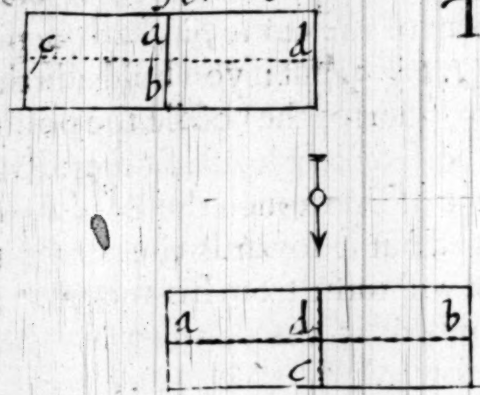
Now take two long *Magnets*, that haue their poles in the end, and place a needle before the æquator of one of them, and it will apply paralell to the *axis*, then bring the other *Loadſtone*, and place the end where the pole is againſt the æquator of the firſt *Loadſtone*, as *Ta. VIII.Fig.5.* and then the needle will vary his poſition, and ſeate it ſelfe at right angles, to the *axis* of both *Magnets*.

So alſo take two *Loadſtones*, and let one of them haue the poles in the middeſt, and the other in the ends, and you ſhall behold much artificiall variety of the application of one needle vnto them. Place a needle before the middeſt of the *Loadſtone*, that hath his poles in the middeſt, and it will behold the pole: after lay downe the other *Magnet*, that hath his poles in the ends, and ſet his æquator againſt the needle, and it will vary his poſition, and ſtand paralell to the æquator of the former *Magnet*, whoſe pole he beheld before, as *Table VIII.Fig.6.*

Apply a needle to the end of a *Magnet* that hath his poles in the middeſt, where it will place it ſelfe obliquely vnto the ſtone, then place the æquator of the *Loadſtone* that hath the poles in the end, *Tab.IX.Fig.1.*

Tab: IX

fi. 1



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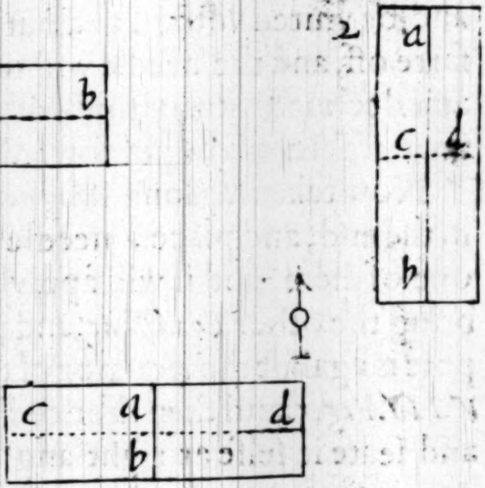

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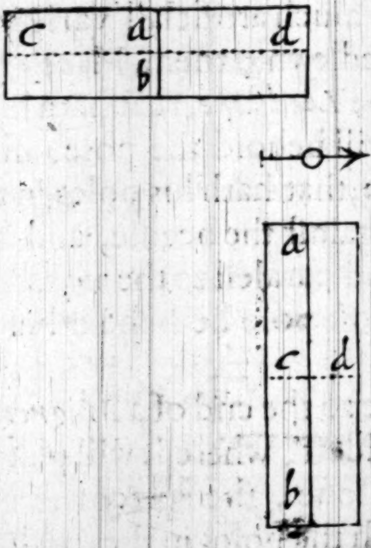

vnto the needle, and it will vary paralell to the *axis* he firſt beheld, and at right angles to the *axis* of the ſecond ſtone.

Set a needle againſt the end of the *Load-ſtone*, that hath his poles in the ends, and it will reſt it ſelfe at right angles to the *axis*, then apply the ſecond *Magnet* to the needle that hath his poles in the middeſt, *Tab.IX. Fig.*2. and the ſituation of the needle will be altered to be paralell to the *axis* he beheld at right angles at firſt.

Place at the corner of that ſtone that hath the pole *B* in the middeſt, a needle, and it will apply obliquely, then lay the end of the other *Loadſtone* that hath the pole *A* in the end, and the needle will apply at right angles to the *axis* of both the ſtones, as it is *Table IX. Figure* 3.

But ſet a needle afore the end of the ſtone that hath his pole *B* in the middeſt, and ſet the end of the other *Magnet* that hath in the end the pole *B* of the ſame denomination, as *Tab.X. Fi.*1. and the needle will apply, as is to be ſeene in the type in a ſtraight line to the laſt, and paralell to the *axis* of the firſt.

Alſo apply the æquator of this ſecond ſtone, that hath the poles in the endes vnto the needle, placed as afore, vnto the firſt ſtone, *Table X. Figure* 2. and the needle will be paralell to both *axis*, let the needle ſtand againſt the corner of the firſt ſtone obliquely, and apply the end of the ſecond ſtone with the pole in it, *Tab. X. Fig.*3. and the needle will apply, as in the *Tab. IX. Fig.*3.

Tab: X

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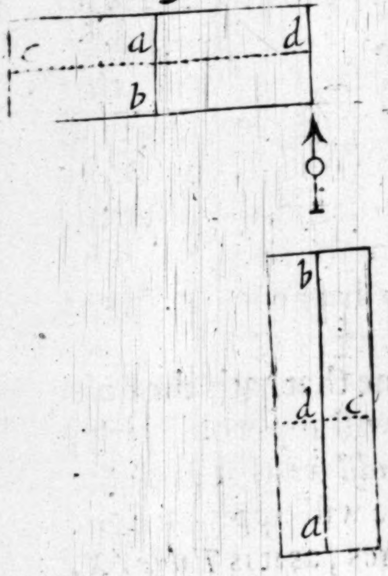

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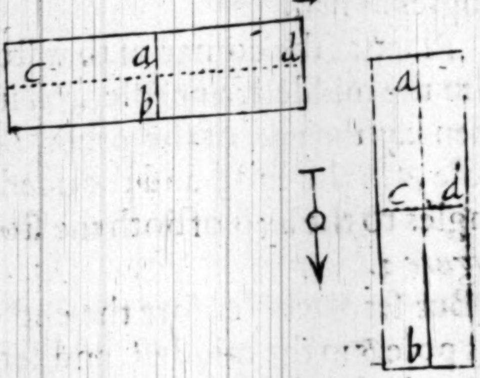

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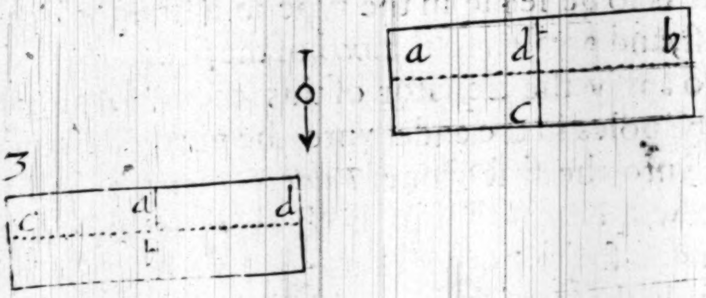


CHAP. XVI.

Of preſeruing the vertue of Magnets.

HAuing treated of the parts of the *Magneticall* bodies, of their motions, and applications, now we will ſpeake of his other naturall vertues and properties. Some haue thought it very conuenient to keepe the *Loadſtones* in filings of ſteele and iron, to preſerue their vertue and vigor, thinking that the *Magnet* is fed, or, at leaſt, very much refreſhed with them, becauſe they will cleaue ſo faſt to the ſides neere the pole; But I do not allow this way ſo good to preſerue them, rather I like the keeping of them in a bag, or cloute of woollin-cloth, cloſe from the iniury of the heate and cold of the weather, or in a caſe or boxe fit for them, and it is very neceſſary to wipe them often from duſt and greaſe, and to haue a care that they do not ruſt.

Alſo it is very commodious and naturall for them that they be layde vp, and placed according to that naturall ſituation the which they would affect and reſpect, if they were caried in a place and faſhion free from renitency and reſiſtance in the aire or water; therefore they would be laide vp, or hung accordingly as their poles and pointes do particularly reſpect, to the North and South, which will comfort them exceedingly.

Beſides, if the *Loadſtone* be ſometimes poliſhed, it will ſtrengthen and releeue the body of the *Magnet*:

very much. If a weake *Magnet* be rubbed at one of his poles with a ſtronger *Loadſtone*, he will be bettered by it in his vigor and vertue, if not augmented therein.

Set a *Magnet* of no force or ſtrength, that can eaſily be perceiued, vpon a *Loadſtone* of good ſtrength and vigor, eſpecially vpon his poles, and he will ſhew a vigor, as if he were as ſtrong as the *Loadſtone* is, whereunto he is vnited, but after that he is taken away, he will be as weake as before, vnleſſe it be often done.

CHAP. XVII.

Of contributing the vertue Magneticall to Iron or Steele.

THe iron barres in windowes, being there placed North and South, do receiue a polar vertue, and directory faculty in time from the vigour of the orbe of the *Magneticall* globe of the earth, and hauing marked them with notes to know which end was South, & which North in the window, take them out and tye a thrid about the middeſt of them, that they may hang leuelly in the aire, and the end with the South note will turne it ſelfe into the North, and the other note will behold the South, contrary to their place in the window, where they were firſt animated *Magnetically*.

Likewiſe, if a long peece of iron be forged North and South, and laide by to coole in the ſame ſituation, he will be animated and indewed with a polar vertue, and moue in the aire,being hung in a thrid,or put in a boate on the water, and turne to the contrary pole to that from which he firſt receiued the *Magneticall* vigour.

If a rod of iron,a wier,or directory-needle,be ouerheat in the fire, ſo that they haue loſt all *Magneticall* vigor to direct them North or South, yet let them be touched with the *Loadſtone* at one end only , and they will be excited with a directory and polar vigour at both ends , and the one end of the ſemidiamiter will be of the North, and the other of the South prouince and nature,and being placed according to *Magneticall* orders,will direct their points to the North & South, contrary to the pole that animated them with this vertue polar.

Alſo take rods of iron,wiers, and *Magneticall* needles, that haue neuer bin touched with the *Load-ſtone*, and rub them vpon the poles , caps, or teeth of the *Loadſtone* at the ends,and they will be much refreſhed, vigorated, and animated with the polar and directory vertue at both ends , both of the North and South-poles, as though they had a new life of quickneſſe infuſed into them , and theſe ſhall refreſh other needles that ſhall be touched with them , and apprehend and draw them away like captiues , and will not let them looſe from them, vnleſſe by force you ſeuer them.

The beſt way to touch, incite,and giue the polar directory and *Magneticall* vigour and faculty vnto needles & Marriners compaſſes, is to rub them from the middeſt of the needle where the æquator of their *axis* is vnto their points vpon the pole,cap,or tooth of the *Loadſtone*, drawing them thus from their middle to the ends, vpon the cap, pole, or paralell neere the ſame, vnto the *axis*, or at right angles to it, thē after draw the other end vpon the other pole, cap, or tooth, diuerſe times, as afore, and theſe needles, wiers, and plates for compaſſes, ſhall be perfectly touched and vigorated.

In long *Loadſtones* that haue the poles in the ends, if a wier be drawne paralell to the *axis*, from the poles end to the æquator, it will be incited with that pole.

It is doubted whether the touch and polar vertue wil be giuen as wel from a paralell ſome diſtance from the pole, as from the pole it ſelfe, it is plaine, that from thoſe paralels and parts, neere adioyning to the pole, the greateſt vigour of politic *Magneticall* doth proceed, yet in paralels, neerer the æquator, it will be giuē likewiſe, & the vertue directory will be very ſufficient.

If you touch the needle amongſt the paralels, it is the beſt way to rub the needles alongſt the meridians towards the pole, rather then to rub the croſſe the meridians, in a paralell manner, yet this way will giue the polar and *Magneticall* vertue alſo.

Some haue thought it better to touch compaſſes, and *Magneticall* needles, rather on the *Loadſtone* then vpon their caps, thinking that the vigor and faculty *Magneticall* will continue longeſt that is giuen from the bare *Magnet* ſtone, the truth is to be obſerued in time. Yet the cap and tooth giueth and imparteth a ſtronger vigour to the needles then the bare ſtone doth, becauſe the vertue of the *Loadſtone* is increaſed as much by the armor and cap as if his bulke ſimply were tripled.

Needles and wiers of ſteele, heated to an height, and reduced backe to a blewiſh colour, will receiue a ſtronger touch, and retaine it ten times longer then iron will, howſoeuer he be hardned, yet iron is beſt for caps placed neere the ſtone.

That end of the needle, whether directory or inclinatory, which is to be touched, ought to be ſomewhat lighter then the other, eſpecially for the North, and moſt vigorous touch end of the ſtone, becauſe that the touching will ſway downe a little, and the needle hath two motions, one of direction, the other of inclination, and then the needles and compaſſes will play more leuell and æquidiſtant to the horizon for the ſayd vſes.

When any *Magneticall* needle or wier is touched from the North-pole, or tooth of the Adamant, that end of the needle will reſpect the North-pole of the *Magnet*, but being ſeuered out of the orbe of the Adamant, it will be directed into the South by the *Magneticall* vertue of the earth.

But if a round globe or ring of iron be touched with the North-pole of the ſtone, the place touched will haue the vertue of the South-pole, & the North-pole will be in the oppoſit part, and being ſeuered from the *Magnet*, it will not turne to the contrary part, as it falleth out in long *Magneticall* needles & compaſſes, as before.

If a ring of iron be touched, the correſpondent pole will be in the oppoſite part, but if this ring be cut aſunder, and made a ſtraight wier, then both ends will haue the vigor of one pole onely.

Excite a directory needle at both ends from one pole, and they will both be of one nature, and looke what point was laſt touched, and that will turne, as if he onely were touched, and direct more ſurely, with leſſe wauering too and fro, then the other touchings will, ſpoken of before.

Let a long peece of clay newly burnt, coole North and South, and it will receiue power *Magneticall* from the earth.

Set two *Loadſtones* with their poles of one denomination, at the ends of a peece of clay whileſt it cooleth, and both ends will be of one nature.

If a long wier be touched in the middeſt by the *Loadſtone*, and paſſed through a corke, and ſet for to ſwim in the water, it will wauer vp and downe vncertainely; as though it were not touched: but if it chance to reſt it ſelfe towards the pole, in time it will be indewed with his vertue.

Set a peece of iron vpon a *Loadſtone*, as you did a weake *Magnet* in the end of the former chapter, and it wil haue a great force, but take it away from the ſtone, and almoſt all the vigor will be departed.

CHAP. XVIII.

Of augmenting the vertue of the Magnet.

THere is a meanes found out whereby the *Load-ſtones* that will take and lift vp a very ſmall waight, may by being armed with a corſelet and teeth, be enabled to take vp more ounces with his armor, then he could, being naked and vnarmed, lift vp ſcruples and graines.

The firſt way is by faſhioning caps of iron or ſteele to either pole, as hath bene deſcribed, *Tab.I.* in the ſecond Chapter, whereby the *Magnet* will lift vp a great weight of Iron at one end perpendicularly to the *axis*, and after, if you turne the other end to the weight, it will by his force lift vp the ſame weight alſo, if the ſtone be good and of equall ſubſtance and faſhion.

This way or arming is moſt vſuall, for thoſe *Load-ſtones* that be of a long ouall forme where at the poles there is fitted and placed two concaue peeces of ſteele, which are faſtned and held cloſe to the ſame by three or foure long narrow plates of ſiluer or braſſe, not vnlike to that order which is vſed in tipping of cuppes with ſiluer, that be of Oſtridge-egges, Indian-Nuts, Mace-wood, and Stone, which from the bottome to the verges and edging, haue ſiluer plates for to hold the edging and bottome together: ſome trimme their *Load-ſtones* all ouer with ſiluer, and guild both the ſiluer and the armour, ioyning altogether with pretty ioynts, as in a caſe to open and ſhut.

There is another way of capping and arming of *Load-ſtones* when they haue a ſide parallell to the *axis*, made ſtraight, plaine, and flat, and the pole rounded or flatted in the end, ſuch as are the *Semiterrella*, or halfe ouall forme. *Tab. I. Fig.* 2.4. and of many angles, as in the types of the firſt Table, all theſe formes may haue their armour on the ends, where the poles are of ſuch breadth, as ſhall be comely, but the larger they are, the better it is, and from theſe cappes to haue two ſquare formes of Steele or Iron, like vnto teeth, a little deſcending lower then the bottome of the ſtone, of bignſſe and length, as the bulke of the *Magnet* ſhall permit, theſe teeth becauſe that they do deſcend at right angles from the poles, will iointly take vp great weights, *Tab. XI. Fi.* 12.13. parrally to the *axis* of the *Magnet*, and yet at one of the teeth *Tab. XI. Fig.* 11. will lift vp as much as any cap doth directly, and in one *axis* from the pole, the weights for this forme, ought to haue the heads of their weightes, like an headleſſe croſſe, as is deſcribed, *Tab. II. Fig.* 2. 3. 4. Heere obſerue what weight one of theſe teeth will eleuate in the aire, for both teeth ioyntly lifting and holding one weight together, will take vp from the ground foure times as much in weight. There be ſome *Magnets* that will take vp with two teeth, ſixe times as much as one tooth ſhall, and one I haue ſeene that will take vp twelue times as much with both teeth, as hee will do with one tooth, theſe teeth are to be faſtened to the ſtone, with plates of ſiluer or braſſe, by the skilfull workeman.

Such *Magnets* as be made plaine at both ends, hauing the *axis* in the middeſt of the ſtone, *Tab. I. Fig.* 5. 6. 12. may haue their armour with teeth on both ſides, two teeth on the one ſide and two on the other, theſe will take and lift vp with like ſtrength on both ſides.

More-ouer, the vertue of the *Load-ſtone* may be further augmented, by increaſing the number of teeth and ſhaping them ſo, as that they may take hold with foure or fiue teeth, as *Tab. I. Fig.* 7. and *Tab. XII. Fig.* 11. where the poles being in the ends of the ſtone, and haue had two teeth deſcending on either ſide, now the ſides be turned, and theſe are alſo turned, in forme of a *Greeke* P Π, and the ſtone hath his force multiplied and is made to take vp with foure teeth, hauing two teeth deſcending from either end where the poles are, which two teeth, are of one nature, and the other two of another.

The other faſhion for to take vp with fiue teeth, as it were a hand with fiue fingers, muſt haue the pole in the midſt of the ſtone, which being made, the bottome muſt haue his cap, for this part, to haue three teeth, like a *Slauonian* T ┌┬┐, as *Ta.XII.Fi.*12. and the other cap from the top muſt deſcend with two teeth like a *Greeke* P ┌┐, as in the type.

There is a way to cap the *Loadſtone*, ſo that it ſhall take vp with eight teeth, vſing foure at one time, and foure at another, the ſtone would haue two broad ſides where the poles are, and the teeth would bee in forme like a *Romane* X. or S. *Andrewes* croſſe the center hereof would be placed on the pole, and the teeth artificially faſtned.

If there bee two *Load-ſtones* that bee capped with their teeth deſcending from either end of like Diameter and length, then place theſe teeth together that be of a contrary nature, *Tab.III.Fig.*12. and *Tab. XII. Fig.*10. and they will vnite and adheare together, and if they continue thus ſome time, the weaker will lift vp a better weight.

CHAP. XIX.

Of the decay and decreaſing of the Magnets vertue.

THe vigour of the *Load-ſtone* is much diminiſhed by the euill keeping of it, as when it is laid in the open aire againſt the heat of the Sun, and ſubiected to cold, and all change of weather, or laid vp, as ſome do, in a boxe with ruſty fylings of ſteele and yron, in a place neere a pan of char-cole to keepe it warme in winter.

There is nothing that hurteth the *Load-ſtone* more then the fire doth, for if the *Load-ſtone* be burnt in the fire it will leeſe all his *Magnetical* vertue and ſtrength, the which may be a little reſtored by touching a good *Magnet*, and how weake ſo euer he be, he will be a conuenient *Magneticall* medium, to carry the extent of the *Magneticall* vigour to a farther orbe.

Aqua fortis will eate the *Load-ſtone*, and burne and mortefie him, as he doth eate into Iron.

The *Magneticall* Needle being touched and excited by the *Load-ſtone* will not purſue and point out the vaines of ſuch Iron as be very ſtony and full of droſſe, as not worthy the labour to be digged, becauſe they haue little *Magneticall* matter and Iron in them, and if that part of the Myne of Iron be beate and ſtamped into powder, the *Magnet* will take vp very little of this duſt, declaring the Myne to be nought, vnleſſe the Myne be heat.

Crocus Martis wil not be attracted by the *Load-ſtone*, becauſe his *Magneticall* vigour is cleane defaced and euaporated by the fire.

If a *Magneticall* Needle, lately touched and inuigorated by the *Magnet*, bee heated red hot in the fire, he will leeſe all his potency polare, and directiue faculty.

It is alſo conueient to vnderſtand, that hauing touched and animated a Needle *Magnetically*, if contrary to this excited, the Needle be rubbed from the point to the middeſt vpon the pole of a *Magnet*, cap, or tooth; ſo any long peece of Iron, or Steele elſe, as knife dagger, or ſword, which before would haue attracted and lifted vp *Magnetically*, other Irons of ſome weight by being thus rubbed backe againe from the point to the middeſt, haue that vertue taken away, which they receiued before from the *Load-ſtone*, and are as void of all vertue attractiue, as they were before they touched the *Magnet*, ſo that they neither will adhere or lift vp the leaſt weight, which was nothing to that they would haue done being excited.

If two *Magneticall* bodies be ioyned together at their poles, theſe two poles that touch together, haue the nature of the æquator, and will not then excite or hold a needle thus touching.

An Adamant doth looſe much of his ſtrength, if hee bee diminiſhed, and haue any part of his body taken from him, eſpecially if his figure was good before.

Some haue thought that certaine formes of the *Magnet*, which may be allowed for conuenient figures, do leſſen the *Magneticall* vigour, chiefly in their attraction, as a ſphericall or plaine ſuperficies in the poles, of globes, and of ſquare and angulous figures, but theſe full and obtuſe ſuperficies and flat formes at the poles do attract beſt with their cappes, and lift vp moſt, as hath bene declared in the eighteene chapter before, for this vigour proceedeth from the ſubſtance of the Adamant, better then in long and piked formes, which haue very little ſubſtance left about the poles, yet this aſſertion is partly true in ſuch like formes of Iron, for in this mettle the long faſhion is beſt.

A round plate of Iron to the pole, cap, or tooth of the *Magnet*, diſperſeth and diminiſheth the direct extent of his vigour, like-wiſe a long plate, or ſquare peece of Iron or Steele, *Tab. II. Fig.9.17.* applied to the two teeth of the *Load-ſtone*, doth deforme the figure of the body and depraue his vertue.

CHAP. XX.

Of the Commutation of the vertue Polar.

THe Polar vertue is ſaid to be changed, when as the North-pole is made the South-pole, and the South-pole altered into the nature of the North-pole in *Magneticall* bodies; this thing is effected, in a weake *Magnet*, by placing him a long time by a *Magnet* that is ſtronger, vnnaturally, which is done by adioyning the two North-poles, or the two South-poles of the two *Load-ſtones* together a long time, where the ſtrong *Magnet*, will by his neighbour-hood take away that contrary nature of pollity that was in the weake *Load-ſtone*, and will make, and infuſe into him that polar vertue, which doth naturally vnite vnto the pole of the ſtrong Adamant, making that point and pole to be South which was North.

This thing is not onely experienced in two ſeuerall *Magnets* lodging together in one chamber and boxe, but alſo if you ſhall agglutinate and cement diuers *Magnets* of diuers ſtrengths together, they will all of them be conioyned and vnited together, as if it were one ſtone and body, and may bee made and faſhioned into a conuenient figure, and will be endued with one vigour *Magneticall* of one prouince, though ſeparated they were of diuers polities and iuriſdictions.

Magneticall needles and long formes of iron, as kniues, daggers, wiers, and ſuch like, if at one time they be touched and excited with the North-pole, and made of his nature in all operations *Magneticall*, then another time let theſe North points be touched, as is vſed to be done with the South-pole of the *Loadſtone*, this end now hath loſt his former nature, and is made of affinitie and allegeance vnto the South-pole, and after if you ſhall beſtow vpon him, by touching him againe at the other pole, the vertue of the North-pole againe, and then he will march vnder his banner, and looke by which pole he is laſt touched and relieued, he will remaine at his ſeruice alwayes after and beare his badge. Put clay of a long forme in the fire, after let him coole North and South, and it will receiue a polar vertue: after burne it againe in the fire, and let that end which cooled firſt North now coole South, and it will be commutated into the nature of the South, and the other North. Furthermore if a ſtrong *Loadſtone* be held ſomewhat neere ſuch compaſſes and needles, as haue bene excited and touched with the vertue directory from the north by the *Magnet*, although they be in their boxes, yet the other end of the *Loadſtone* will alter their ſituation, and the Lilly of the Compaſſes will be cleane turned, that that part and Lilly that ſhould alwaies turne North, will either ſtand South, or elſe moue vp and downe vnperfectly, and weakly, hauing his firſt polar vertue changed for another, or elſe taken away.

This concluſion maketh many affraide to let two *Magnets* come too neere together, leſt the one ſhould rob the other, but this will not be effected preſently in the *Loadſtones* themſelues, though that it be proued ſoone to come to paſſe in the *Magneticall* bodies of ſteele and iron.

If a directory-needle be excited at both ends from one pole, it will haue the vertue of that pole at both ends, but if both ends be rubbed backe from the points to the middeſt, on the ſame pole, both ends will haue the nature of the contrary pole, and if one end be paſſed from the point to the middeſt, that end will haue the nature of the contrary pole, and the other end will keepe his nature ſtill.

CHAP. XXI.

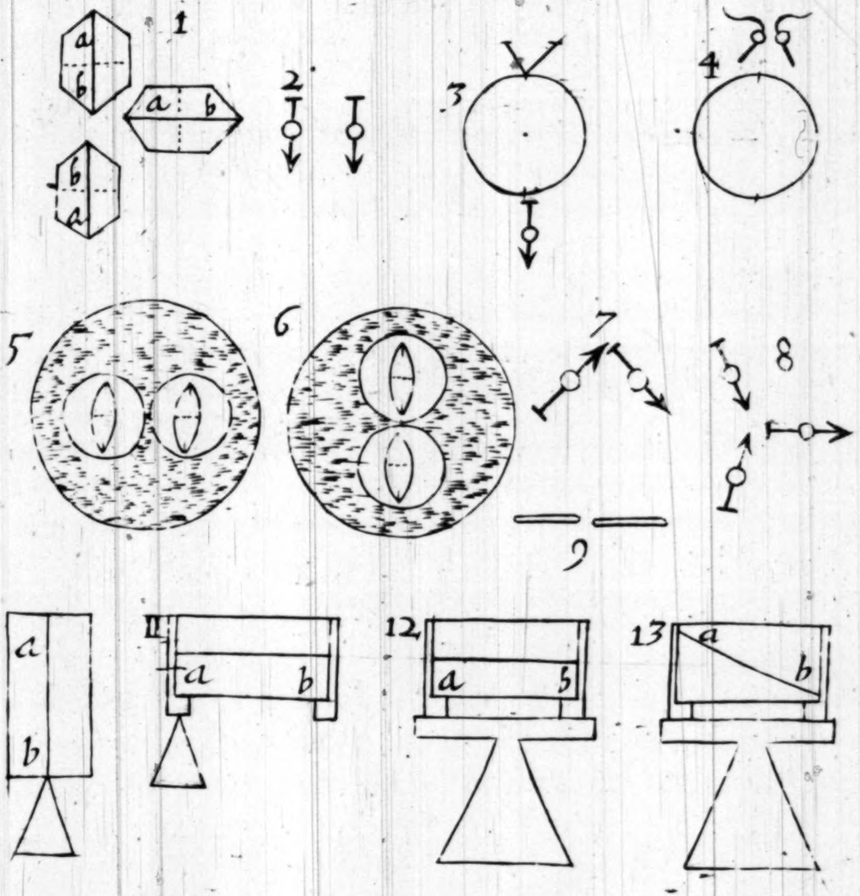
Of the diſcord of the two Points of the Adamant.

THis Propoſition is demonſtrated by two *Magnets* ſwimming in their boates, in a baſon of water, as *Tab.XI. Fig.* 5. 6. for if by force, their two North-poles or South-poles be placed together, they will abhorre the one the other, and part aſunder by ſpeedy flight.

If a ſmaller peece and part bee taken away from a greater *Magnet*, of whoſe body and bulk he was a part, animated, as it were, liuing and endued with one and the ſelfe-ſame life and vigour with the whole *Magnet*, like a child, that liueth and is nouriſhed in his mothers wombe, as a part of the body of the mother, yet being ſeuered and taken out of the greater *Loadſtone*, doth become a compleat *Loadſtone* of it ſelfe, as a perfect

new

fig= Tab XI



new borne creature,with all the vigour and lineaments of his owne,belonging to a perfect *Magneticall* body, notwithſtanding ſuch is the nature of this little,and this greater *Magnet* , that their loue and agreement,in their vertues and points, is not ſuch as it was in their vnion in one body, but their kind aſpect,all one way is altered to bee at diſcord, and if you ſet South-pole to South-pole, and North-pole to North-pole, you ſhall force them to tarry other-waies, like as if they were foes at diſcord they will ſwimme away and flie aſunder very ſpeedily, not enduring ſo to conſort together as they did at firſt when they were both one body.

When two Adamants ſhall conſort, and keepe together, at their contrary poles, at the approching of a third *Magnet* they will be ſeparated and flie aſunder *Tab.X I.Fig.*1. becauſe that the pole of their Adamant, that is offered vnto them, is of the nature of the pole of one of the two *Loadſtones,* which the ſtone of that denomination perceiuing, flyeth away from the company of the other, becauſe two South-poles and two North-poles, in diuers *Magnets,* be at diſcord and war together, and cannot abide to dwell as neighbours together, but each of them, placed out of the others Orbe; will both aſpect the North, with their North-poles, and the South with their South-poles, and thus two needles excited as *Tab. X I. Fig.* 2. will each of them, out of the others Orbe, haue reſpect to their propper pole, but if the needles bee within the Orbe one of the other as *Tab. X I. Fig.* 7. then they will moue and adhere together at their contrary poles, but if a third Needle be brought neere vnto them as *Tab. X I. Fig.* 8. then one of thoſe Needles that did adhere, that had his pole of the ſame nature, with the pole of the needle that doth approach, doth caſt about for to offer his other end of the contrary quality vnto it, and thus the firſt two Needles will aſpect this third with their points of one denomination.

But this diſcord is not found betweene the Adamant, and the *Magneticall* Needles that bee excited and animated from one of his poles, for as long as the Needles bee within the view and orbe of the Adamants

mants *Magneticall* orbe, ſo long they will behold and aſpect him with a certaine dutifull conformity, application and reſpect vnto his *axis*, as it hath beene demonſtrated in *Globous* & *Angulous Magnets*, but being ſeuered out of the Adamantine Orbe of the *Loadſtone*, then they will flie, as from a foe, from that pole from whence they receiued their life and vigour *Magneticall*, and by the vertue of the earth conforme themſelues to the contrary pole.

Contrariwiſe, take a large Globe or Ring of Iron, and touch them with the North-pole of the ſtone, and the animated place will haue the vertue of the South-pole, and adhere to the North-pole of the *Magnet*, and being ſeuered will keepe the ſame ſituation in the water, contrary to all Needles that turne the touched part to the contrary pole, as afore.

Set two ſhort and ſlender wyars vpon the pole of a *Magnet*, *Tab. XI. Fig.* 3. and they will adhere at the lower end vnto the ſame, but whereas they ſhould erect their other ends perpendicularly, thoſe ends of the wyers will decline a great diſtance aſunder, vnleſſe by force they be vnited and ioyned together.

Contrariwiſe it will fall out if theſe two ſhort wyers bee faſtened to two ſeuerall thirds with wyer, and hanged ouer the pole, then neither of their ends will behold the pole, but for the hatred that the one beareth to the other, they beare off aſunder in a great diſtance, deſiring rather that their vpper ends, fartheſt from the, *Loadſtone* ſhould vnite, then that they ſhould doe it.

Hold a knife to the Needle of a Dyall that is touched *Magnetically*, and the one point of the Needle will come to it and follow it, and if that the knife bee offered to the other end of the Needle it will flie away from the knife, ſo one end of any wyer, though vntouched, will attract the Needle at one of the ends, and driue the other end away, Hereof more hath bene written in the ſixth Chapter. Some thinke that this quality of the poles, thus to flie off the one from the other, that it is no enmity, but proceedeth from a diſponent vertue, to cauſe theſe *Magneticall* bodies to moue and turne away, to the end that they may better frame and diſpoſe themſelues to a conuenient and naturall vnition.

CHAP. XXII.

Of Magneticall Vnion.

Magneticall-vnion is when one *Magneticall* body naturally conformeth it ſelfe to vnite vnto any other *Magneticall* body, by conuenient angles & poſitions, that is, the South-pole of the one *Magnet* will apply and vnite vnto the North-pole of the other, as may be ſeene in *Loadſtones*, carried in their boates vpon the water, and in *Magneticall* Needles and Wyers of Steele and Iron.

If two *Magnets*, or two Needles do vnite at conuenient points, a third *Magnet* or Directory Needle will firſt ſeparate one of them till hee turne his contrary part, at the which hee will vnite with the third as *Tab. XI. Fig.* 1. 8.

There is a ſtrong vnion, of body to body, and a weak, the ſtrong coniunction is three manner of waies.

The firſt is commonly obſerued to bee at the Poles, where one body *Magneticall* is conioyned and vnited vnto the other in a right line,vpon the *axis* at the pole, *Tab.XI.Fig.*10.

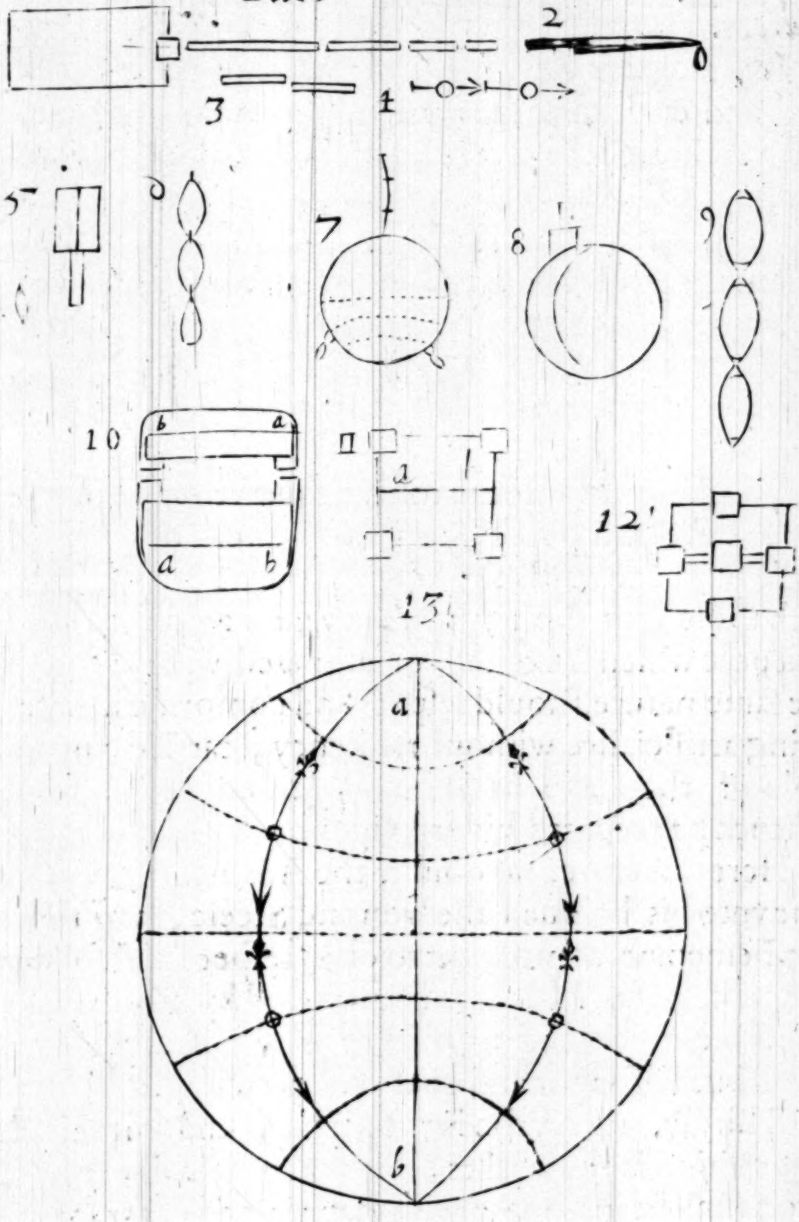
The ſecond ſtrong vnion falleth out when the ſuperficies where the pole is placed is made plaine,whereat the edges,*Magneticall* bodies adhere at right angles vnto the *axis*,as *Tab.III.Fig.*11.and *Ta.VII.Fi.*2.but more plainely, this ſtrong vnion appeareth when as the Adamant ſhall be capped with two teeth at either pole, deſcending at right angles vnto the *axis*, for here a tooth will lift vp as much perpendiculerly at right angles to the *axis*, as it will at the pole in a right line. *Table XI.Figure* 10.11.

The third ſtrong vnion, and ſtrongeſt, is when at a Meridian in the *Loadſtone* there is a ſuperficies made flat and plaine, paralell vnto the *axis*, where the coition according to the conformity in the æquator, inclining neither to one pole, nor to the other, is moſt ſtrong, for whereas wyers and weights,at thepole, hang and adhere vnto it, but by one end onely, heere they will adhere alongſt their *axis*, leaping more violently to adhere with their whole ſide and vnite, then they will from their endes vnto the poles, as *Tab. III. Fig.*4. therefore the Adamant being armed artificially with two teeth, at right angles vnto the *axis*, will in this paralel-conformity vnto the *axis*, apprehend and lift vp weights heauier by many times, then the caps at the poles will,*Tab.XI.Fig.* 12. becauſe theſe receiue their vigour from the forces ſent out of both Prouinces of the *Magnet*.

The weaker vnition of *Magneticall*-bodies together is in the other parts of the Meridians, where the conformity and applications of their bodies is oblique to the *axis*, though that neere the pole, the oblique coition is ſtronger then it is by the æquator, Notwiſtanding, there is an oblique coition, as ſtrong as the ſtrongeſt vnion, and will take vp as great weights, as the paralell vnition to the *axis* doth, and this is, as it were, a paralell coition alſo betweene the teeth and the head of the weight, yet oblique to the *axis* of the body of the *Magnet*, as *Tab. XI. Fig.* 13. hauing his ſupplies of ſtrength from all the *Magneticall* body of the ſtone.

Vnition alſo, is either naturall, halfe violent, or elſe depraued; the naturall coition is when the vnion and conioyning of *Magneticall* bodies is by the contrary parts, as in Adamants, by the poles North to South, and in needles by head and taile, as *Tab. XI. Fig.* 7. *Tab. XII. Fig.* 5. 6. 9. ſo two wyers ſwimming on their corkes in the water, being touched by contrary poles, will march and haſten to ſalute one the other, like two louers, *Tab. VI. Fig.* 5. Likewiſe in Adamants that be armed with two teeth, it falleth out that they will embrace the one the other, onely with the teeth and parts that be of contrary prouinces, and not with thoſe of like nature and prouince. *Tab. III. Fig.* 12. *Tab. XII. Figure* 10.

The halfe violent coition, when as a ſmall *Loadſtone*, which hath bene taken out of the ſide of a greater, is placed in his former ſeate againe, where there is made a perfect vnion againe in one entire whole; ſo in the two ſhort wyers that ſticke vpon the pole, being heere vnited, but at the other ends flie off aſunder, yet being put together by force, will adhere and haue an vnion and coniunction alongſt their ſides and Meridian fi, Tab. XII



dian, as well as in the other way of vnition. *Table X I. Figure*.3.

Now that vnition, which *Magneticall* needles touched and excited at the pole of the Adamant haue, may bee thought to bee halfe violent and ſome-what ſtrange, *Tab.III.Fig*.1.6.7.*Tab.IIII.Fig*. 1. becauſe that heere there is an affinity of two *Magneticall* bodies of the ſame nature and denomination, and not of the contrary, that it ſeemeth that the *Magneticall* nature, betweene the Adamant and the Iron, is both very different from all other *Magneticall* bodies and ſome-what imperiall; for it is not to be ſeene either in *Magnets* one towards the other, though they be of the ſame rocke and peece, or in any wyers of yron or ſteele of one towards the other, or in the earth it ſelfe, with thoſe that ſhe doth *Magnetically* animate, that that pole which is excited, or animated with a pole of the ſame nature, ſhould reſpect and conforme it ſelfe, being artificially, without renitency, carried vnto a pole of the ſame nature and denomination, from whence he receiued his firſt vigour.

Here therefore, no doubt, the Adamant is Maſculine vnto his beloued the Iron and Steele, and theſe are Femenine, as more apt to obey, reſpect, and follow the Maſculine, ſubiect to be attracted by him, whoſe preſence quickeneth, reuiueth, and animateth them in all kind of vigor and commutation.

Thirdly, when yron is vntouched, and vnexcited, the coition is the weaker, but when a ſmall peece of Iron ſhall be in a boate, with materials of other lading to be vnited to a *Magnet* in his veſſell, heere the coition is depraued and weake, becauſe the *Magnet* affecteth and draweth his owne beloued beſt, when ſhe is not laden or mixed with materials that be of different nature not *Magneticall*, and for this cauſe the Adamant will take vp a greater weight, all of Iron or ſteele, then when a great weight of other ſubance, is faſhioned to a ſmall weight of iron or ſteele.

The greatneſſe of the bulke of the Adamant helpeth vnition, ſo doth the length of the *axis*, and vertue diſponent to ſet the *Magneticall* bodies in conuenient ſituation.

Beſides, there is a vertue attractiue, beſides the diſponent vertue, and a directiue and inclinatory faculty in the Adamants, that bring *Magneticall* bodies to vnition and apprehenſion, the two firſt retaine them in vnion and coniunction, proceeding eſpecially from the goodneſſe of the ſtone, the latter two helpe the diſponent vertue, and are to be found in all *Loadſtones*, and in the earth it ſelfe.

CHAP. XXIII.

Of attraction Magneticall.

M*agneticall* attraction is a naturall incitation and diſpoſition conforming to contiguity and vnion of one *Magneticall* body vnto another, and no violent haling of the weaker to the ſtronger, being an appetite of vnity proceeding from both bodies that are ſeparated, as two *Magnets* floating in their boates do not at firſt run together, as it were, from center to center of the bulke vpon a violent diſpoſition or attraction, but the diſponent vertue firſt worketh, then the allicient and Adamantiue vertue in them, both for vnition, doth ſhew his vigor to ioyne them by conuenient termes the one body vnto the other, *Tab.X I.Fig.* 5.6.

Alſo the Adamant doth more ſtrongly attract iron, hauing a more Maſculine nature to attract her, and inableth her, beſtowing vpon the iron, that he toucheth, a great quantity of his ſtrength without any loſſe vnto himſelfe, ſo that ſhee hath power to attract other iron ſtrongly, which before the excitation from the *Magnet* ſhee could not doe, and therefore excited formes of iron and ſteele, are quicklier attracted, then ſuch as are not touched, becauſe they haue more *Magneticall* vigour in them.

Such *Magnets* as be armed with iron, attract more ſtrongly then the bare ſtones doe, becauſe that hereby their vigour is increaſed, being more ſtrong, and extendeth it ſelfe further, as if a long iron wyer bee conioyned to the pole, or tooth of a *Loadſtone,* and to the end of this, lay to another, and at the end of that a third, and ſo forward, the Adamant will hold them all, or moſt of them, according to his vigour and ſtrength, *Tab.X II. Fig.*1. all touching one the other, and cleauing together, as linked in a chaine.

Place a wyer ſome-what ſhort vpon a *Load-ſtone* neere the pole, or further off, and hold an iron or *Magneticall* body towards it, and the wyer will rather bee attracted away by this weaker body, and leaue this ſtrong *Magnet*, *Tab. VI. Fig. 6.* and before the yron touch it, it will decline and bend towards the yron that approcheth, ſo will needles directory deflect awry, being placed vpon the *Magnet*, from their conformity to any vntouched wyer, and be attracted by them, and this proueth, that the eminent parts of the earth being *Magneticall*, may attract the Compaſſe to vary from the true Meridian of the earth.

The naturall attraction of *Magneticall* bodies, is that the North-pole do attract the South-pole, and the South-pole the North, although betweene the Adamant and the iron there is that ſociability, that the North-poles loue one and the ſame pole.

CHAP. XXIIII.

Of the ſtrong apprehenſion of Magnets.

THe apprehenſion of *Magneticall* bodies is a ſtrong vnion, cleauing and ſticking of them together, that they will hardly be ſeuered, being ſtrongly retained by the vertue and loue *Magneticall*, as though they were tied, glued, and ſoudred together, this coniunction and agglutination is performed by certaine conuenient poſitions, whereof I haue ſpoken in the XXII. chapter of vnion; according hereunto if two *Magnets* be ſwimming in their boates vpon the water, within the orbe and vigor *Magneticall* one of the other, they will moue to conioyne and be grappled together like two ſhips, and if one of the veſſels be halled, the other will follow, *Tab.XI.Fig.5.6.*

A ſtrong *Magnet* will hold but a very ſmall *Magnet* at the poles, hauing the North-pole applied to the South-pole, for to lift the ſmall *Magnet* in the aire, but offer a wier of polliſhed iron or ſteele, that is a good deale heauier then the fragment of the *Magnet* was,and the *Loadſtone* will lift this vp from the ground and retaine it firmely, *Tab.XII.Fig.5.*

If *Magnets* be of one mine, the biggeſt will lift vp and hold the greater waight, for this purpoſe the longer forme from pole to pole is beſt, and bulke being compared with bulke, this forme will take vp the greater waight, becauſe his diamiter is longeſt.

Take a long peece of iron or ſteele, as a knife, or dagger, or ſword, that is finely poliſhed, and touch and excite them *Magnetically*,and theſe ſhall take vp a greater waight of iron then the Adamant it ſelfe, ſo it be very good and little ſhall, that gaue them their vigor *Magneticall* to lift vp, and retaine firmely, *Table XII. Fig.2.*

I haue a *Loadſtone* that will vigorate a ſword to take vp and hold a pound waight. Likewiſe *Magneticall* needles and excited wiers will ſtrongly retaine and adhere one vnto the other at their conuenient poles, hale one the other, and lift them vp,and retaine them firmely, for ſuch *Magneticall* formes of iron and ſteele as be touched and animated *Magnetically*, are ſooner apprehended, held faſt, and lift vp in the ayre then thoſe that be vntouched and vnexcited, becauſe that when the *Magneticall* vigour is infuſed, diſperſed and ſpread through all the parts of the iron-waights, or of ſteele, theſe formes are ſooner vnited and faſter tied, as it were, with ſtrong ligaments and cords,both vnto the *Load-ſtone*, or one vnto the other, *Tab, XII. Fig.3.* therefore if ſand or other matter that is not *Magneticall* be faſtened and bound vnto a ſmal peece of iron, or this ſmall peece of iron be faſtned to a paire of ſcales, that haue ſtrings to the ſcales, though iron be the waights of the ſcales: yet the *Magnet* will lift vp and hold a greater waight that is all continued iron, then he will do of theſe mixture and intermiſſion of *Magneticall* medium, of diuerſe and different ſubſtances, not *Magneticall.*

If a *Magnet* be faſtened to the pole of another *Loadſtone* by his conuenient vpper pole then a greater waight then before will be apprehended by the *Loadſtone* and taken vp, becauſe that the *Load-ſtones* vertue is increaſed and augmented by the addition and adioyning of the other *Magnet*, *Ta.XII.Fi.6.9.* Euen ſo, for the ſame cauſe, if a wedge of iron be placed on the vpper pole of a *Load-ſtone*, the other pole that is downward will take vp a greater waight, *Tab. III. Fig. 2.*

If there be a thin plate of ſteele or iron held or faſtened vnto the nether pole of the Adamant, betweene the *Loadſtone* and the waight, then the *Magnet* will lift double, and ſometimes decuple, or ten times as much againe, from this practiſe begun and grew the arming and capping of Adamants with ſteele and iron, after diuerſe manners, *Tab. II.* and as hath bene declared in XVIII. Chapter, *Of the augmenting the vertue of the Load-ſtone*; by this arming of the *Loadſtones* with ſteele and iron in conuenient places, their vertue and potency is greatly multiplied, both to vnite, attract, apprehend, and lift vp greater waights, and alſo to moue, turne, and conforme *Magneticall* needles a far off, and the needles by hauing a ſtrong vigour infuſed into them direct and retaine themſelues more firmely in their conformitie and direction *Magneticall.*

If a plate or cap of iron be held to any paralell betweene the æquator and the pole, croſſing in any meridian, there will be an apprehenſion and retention of iron, wiers, and waights, much heauier then the bare vnarmed ſtone wil hold without this cap, *Ta.XII.F.*7.

Where the ſuperficies of the *Magnet* about the pole is flatted and made plaine, hauing armour applied to it, and a tooth deſcending from the point at right angles to the *axis*, here this tooth will take vp and lift as much as the cap at the pole will, *Tab.XI.Fig.*10.11.

Thoſe Adamants that be capped to take, apprehend and lift vp at the pole onely, if there be three of them readily prouided, put the ſecond to the nether pole of the firſt, and he will retaine him firmely, then adde the third to the nether pole of the ſecond and the firſt, by vertue infuſed into the ſecond, and the third, will ſtrongly hold them both in the aire, *Tab.XII.Fig.9.* all of them being armed and communicating their vigors together firmely to vnite.

So a dagger or ſword excited, will lift vp one waight at the end of another, and if the vpper that touched the ſword or *Load-ſtone*, be held an inch off, yet by the vertue that is extended within the orbe *Magneticall*, the waights will cleaue together ſtill.

Set a ſhort and ſmall wier at the pole of a *Magnet*, and it will be erected, ſet another on this, and it alſo will be caried vpright, ſet on the third, and all three will be apprehended and borne vp, *Tab.XII.Fig.*7.

Alſo ſet a ſhort wier on the pole, and another on a meridian, not farre off the pole, or ſet them vpon two ſeuerall meridians, vpon a ſtrong *Magnet*, then lay another ſhort wier on their heads, & they will hold and carry it, and this alſo will carry another wier vpon his backe, *Tab.XII.Fig.*8.

There be certaine formes of *Magnets*, as the *Semiterrella*, in faſhion of an halfe boule, the long ouall made plaine at the bottome, the long ſquare formes, deſcribed, *Tab.II.* all theſe may be armed and capped with two teeth, at right or oblique angles to the *axis*, which being thus prepared, will apprehend great waights, and retaine them moſt firmely in the aire, *Tab.XI.*12.13.

If two *Magnets*, armed with two teeth apeece, be ſet before vs, the one being ſtrong, the other weake, or much leſſe, whoſe *axis* or diamiter betweene the teeth is equall of like length, then ſet the teeth of theſe together that come from contrary poles and parts, and the ſtronger will apprehend and lift vp the weaker, and the weaker being vnited and incorporated with the ſtronger, by the vertue that he receiueth frõ the ſtronger, will lift vp from the ground, and retaine the ſtronger and greater very firmely, although he be much heuier then the waight, the ſmall ſtone doth ordinarily lift vp, *Tab.III.Fig.*12. *Tab.XII.Fig.*10.

Let a *Magnet* be armed with two teeth deſcending, and two aſcending, as *Tab.I.Fig.*5.*&* 6. the vpper teeth will cleaue faſt to a great waight of iron, and hold by the ſame firmely, apply a waight to the nether two teeth, and all will be retained and held together moſt firmely by paralell vertue of the meridians from the *axis*.

Such *Magnets* as be armed to one ſuperficies, with foure or fiue teeth, or more, *Tab.XII.Fig.* 11.12. muſt needs apprehend more and greater waights, retaine and lift them vp moſt eaſily.

A peece of ſteele well tempered, being excited, will lift vp a greater waight then the like forme and bulke of iron will, alſo this tempered mettall in a kinde of forme might be capped like a *Magnet*.

It hath bene proued that the apprehenſion is better betweene the bare ſtone and iron, as alſo the armed Adamant, with the armed Adamant, is moſt ſtrongly retained, and farre more firmely then the retention of one *Loadſtone* is with another ſmall and bare ſtone.

Now it is to be obſerued that ſteele, by reaſon of his drineſſe, retaineth his vigor *Magneticall*, beſtowed vpon him, better then the iron doth that is ſofter, which entertaineth the vertue *Magneticall* ſooner, and retaineth it the leſſe time where his ſubſtance is leſſe extenſible and glutinous; ſo ſteele being very often excocted and euaporated in the fire, becometh very brittle, and will not receiue the *Magneticall* vigour, yet being reduced from that hardneſſe, and eaſily tempered, not to be ouer hard, will retaine the vigour *Magneticall* better then iron.

Thoſe Adamants are the beſt which are bare and naked, without their furniture and armor to take vp their owne waights, or more, at one of their points and poles, and retaine the ſame firmely. Such Adamants will cleaue vnto a peece of iron by their meridian, and hang vnto it, and will retaine a great iron waight alſo adhering to the meridian paralell to the *Axis*.

CHAP. XXV.

Of Magneticall direction from the earth.

Hitherto I haue diſcourſed of the *Magnet*, and other *Magneticall* bodies, parts, motions, applications, vertues and effects, as they haue one vnto the other, which haue bene of that qualitie, that they might be almoſt all of them experienced and obſerued at home and in our houſes, handling the *Load-ſtones* as little earthes and globes, and turning them about with our hands, to ſee,obſerue,and vnderſtand all the qualities,vertues and effects of the ſame whatſoeuer, comparing theſe *Magnets*,as diuerſe earths and *Magneticall* globes together, with the motions, compaſſions, and concluſions,proceeding from a preſent,perticular,and vnnaturall cauſe and potency in the ſtone before our eyes.

And hauing before partly diſcouered the motions that *Magnets* haue with the earth, being taken out of the ſame, and bred, and animated therein, as alſo the motions of ſuch irons as haue bene excocted out of the mines, and ſuch like veines, or rather bones of the Earth, that haue bene alſo endued and excited with the directory and *Magneticall* vigour from the Earth, both at their firſt forging and forming, as alſo by their placing vpon the ground whileſt they coole, and become tractable with our hands, and their poſition in houſes, windowes and other places.

Alſo I haue ſhewed how this vertue directorie, polar, vigour, and politic is to be giuen to compaſſes for the ſea,& to directory needles, that direct our moueable dials into the meridian line, and to the *Inclinatory-needle*, or any other needle or Mathematicall inſtrument whatſoeuer.

Now I am to declare how ſuch demonſtrations as haue bene learned at home out of the *Terrella* and *Semiterrella magneticall* may be put in practiſe and vſe by ſuch as ſaile to farre countries by ſea, or trauell by land, for their great benefit, both to teach them how to direct their courſe, and to tell them in what place and climate they are in, which thing they may performe and learne very perfectly, hauing the directory in their compaſſes, and the *Inclinatory-needle* in the meridian ring artificially made about them.

In comparing the two *Magneticall* bodies of iron, and the *Magnet* with the earth, the great and mother-*Magnet* of all *Magneticall* bodies, we ſhall ſee and behold, that not onely in the *Load-ſtone* the *Terrella* and *Semiterrella*, but principally in the great *Terra* and *Magneticall* globe of the Earth, there is naturally found the two poles, the North and South, the æquator, the meridians, paralels, axis, and horizon, whereupon all the motions and concluſions that haue bene made vpon the meridians of the ſayd formes in the *Magnet*, are proportionably and agreeably to be found in the *Magneticall* globe of the earth, in paſſing about her meridians, for all *Magneticall* motions are performed vpon the meridians principally, as hath bene ſaid. Therefore place any *Magneticall* body, as is vſed to be done, free from all obſtacles, *Tab. X I. Fig.* 5. 6. that may hinder their motion and conformity, and they will be ſituated conformably vnto the meridian of the earth, becauſe that the earth hath primarily, naturally, & frõ her firſt creation, all *Magneticall* faculty, vigour, vertue, power, and potency in her ſelfe.

And firſt if a *Magnet* whoſe poles are knowne by the Art before taught, be placed in a boate, or boule of wood, and put into a great baſon or boule of water, it will conforme, direct, and ſeate it ſelfe North and South, according to the ſame poſition and meridian that paſſeth directly vnto the poles of the earth; Likewiſe take a *Magneticall* needle that hath bene excited with the Adamant, ſuch as be in moueable dyals, or elſe take the Marriners compaſſe, and place them in quiet ſituation, and they will be directed by the diſponent vertue and *Magneticall* vigour of the earth towards the North,and Southpoles vpon the true meridian circle and line, if there be no obſtacle.

All direction is obſerued by *Magnetical* bodies,eſpecially by the directory-needle and compaſſe vpon one certaine horizon, whoſe center is in a meridian cut by ſome of the paralels, and on this center the needle and compaſſe is ſuppoſed to be placed, being truly peaſed and compoſed, that they may play, turne too and fro, and reſt leuell and paralell vnto the horizon, fitly placed vpon a pin of braſſe or ſiluer, and be well touched and excited, to the end they may be directed more certainely towards the poles vpon the meridian, *Tab. XII.Fig.*13.

All *Magneticall* needles would be touched with a good vigorous and bigge *Load-ſtone*, that being capped lifteth vp at leaſt halfe a pound weight of iron, to the end it may carry the flie and card of the compaſſe more ſtrongly to his true direction and ſituation; all needles and compaſſes that are to be animated and excited with that part of the *Magnet* that ſeateth it ſelfe North, ſwimming in a diſh vpon the water, by the diſponent power of the earth, and being freed from out of the orbe and vertue of other *Magneticall* bodies, theſe are turned and directed by the vigor of the earth into the South vp on the meridian line.

Euen ſo a rod of iron that ſtath bene placed North and South in a window a long time, whereby he hath receiued a true touch of polar vertue from the Earth, being within the orbe of his vigour, and being remoued from this poſition, which would be noted with chalke, and hanging leuelly in a ſtring in the aire, will moue his North part, and ſeate it in the South quietly.

Therefore all *Magneticall* bodies, whether it be the *Magnet* that is taken out of the Earth, or a part of a *Magnet* taken out from this ſtone, that was cut immediatly out of the earth, or any iron or ſteele that is excited, either from the earth, from an Adamant, or from another excited needle, iron, or knife, or long forme of burnt clay, all theſe whatſoeuer receiuing their directiue and polar faculty from another *Magneticall* body, being ſet at liberty artificially in the aire or water, to moue and turne, will ſeate and be directed to the contrary pole they were firſt reuiued by.

Euery part from the æquator to the pole doth giue a polar and *Magneticall* vertue vnto diuerſe formes of iron and ſteele to moue vnto a contrary poſition, by the directiue faculty of the earth.

This faculty directiue is as ſtrong vpon the æquator as elſewhere, though it do not beſtow it to others, being fortified from both prouinces on either ſide, and when the needle and compaſſe ſhall be in the æquator of the earth, becauſe their libration and leuelneſſe is all one with the horizon: therefore here the direction is conformable and ſtrong: but in other places, and neere the pole eſpecially, the leuelling of the needles is more violent, becauſe they would incline and make an angle with the *axis*, and therefore the direction here is thought by ſome to be very weake: yet in this place neere the pole in the *Terrella* and *Semiterrella*, the little needle on his foote beareth himſelfe moſt ſtrongly and ſtiffely, that being with a finger turned awry, it will turne againe to his direction very violently, though inclining to the ſtone, and reſt it ſelfe very ſpeedily, without many turnings to and fro, ſo that neere the pole the direction is very ſtrong, neither by leuelling hindred.

Alwayes and in all places the Lilly of the compaſſe or croſſe of the directory-needle ſtandeth and is ſeated into the North, both in this North ſide, and on the other South ſide of the æquinoctiall line or circle of the earth, *Tab. III. Fig. 9. Tab. XII. Fig.* 13. contrary to the ſyte of the needle neere the *Terrella* or *Semiterrellæ*, becauſe they are touched and excited at that point of the *Load-ſtone* that in his boate reſteth South, and being ſet at liberty from the *Loadſtone* by the earth is turned North, as the point touched at the North-pole of the Adamant is turned South, neither needeth there here any conuerſion of the compaſſes in ſailing and going from one prouince of the æquator to the other, as the needle doth towards the *Magnet* being maſculine, and the needles of iron or ſteele feminine, but the needles to the earth are perfect *Magneticall* bodies, and do keepe their correſpondency with the earth, as if they were *Magnet*-ſtones, or diameters of little earthes: therefore the needles and compaſſes paſſing from one ſide of the æquator to the other, in a meridian and great circle, proceedeth on ſtill in a right line vniformely, onely the points of the needles and compaſſes do take their turnes to be predominant in their direction in their owne prouinces, eſpecially if their leuel would ſuffer the vertue *Inclinatory* to preuaile, which thing is moſt apparant by the *Inclinatory-needle* in his ring, that being on this ſide of the æquator erecteth his lilly aboue the horizon towards the pole, but on the further South ſide of the æquator dippeth his Lilly vnder the horizon, and ſuffereth the

Point to reſpect his owne pole with conuenient angles to the *axis*. But this thing cannot be done by the compaſſe and directory-needle, which lye alwaies paralel to the horizon, but onely is demonſtrable by the ſtone in the 4 and 5 tables before.

This were a fit place, to ſpeake of the order of making Sea-Compaſſes, the inſtruments for *Magneticall* direction, the making whereof is very well knowne vnto Artificers, yet I could wiſh, that they were more artificially made then they are, though the price were ſome-what more, with ſome additions, which wee do partly touch in the Chapter following, and wiſh alſo that the points were 48. in vſe, that euery point might be halfe an hower.

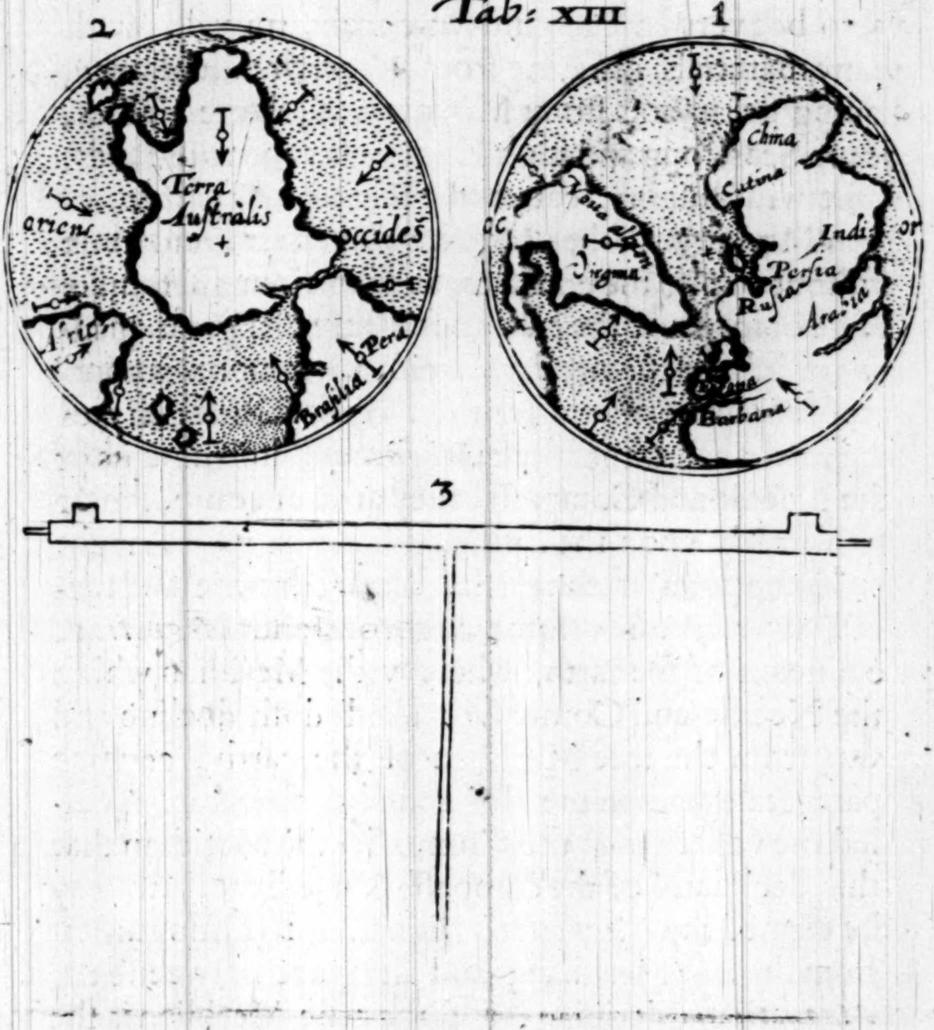
All direction is performed vpon the true Meridian reſpecting directly with the Needle the poles of the earth, as the Needle doth in the good and polliſhed *Load-ſtone* and *Terrella*, vnleſſe it be weakened, depraued, and forced to decline from the true Meridian of the earth, by the cauſes of variation.

CHAP. XXVI.

Of the variation of the Compaſſe from the true Meridian.

THe body of the *Magneticall* Globe of the Earth, is the author and cauſe of all direction, and true motion to the North and South vpon the Meridian, the which would alwaies be certainely pointed out by the directory-needle and

Tab: XIII



and Compaſſe, if the ſubſtance of the globe of the earth were in all parts and places alike, and equally *Magnetical*, as in ſome round *Loadſtones*; neither would there be any variation & declination of the compaſſe and Needle at all, from the true Meridian of the earth, no more then there is of the Needle, vpon a firme poliſhed and round *Load-ſtone*.

But becauſe the Globe of the earth is knowne vnto vs, to bee very vn-euen and vn-equally mixed, with many materials, differing from *Magneticall* ſubſtance, hauing great and ſtony Mountaines, large Vallies, deepe Seas, long and high Continents and fore-lands, ſome with mighty ſcattered rockes of *Loadſtone*, of Iron-Mines, and other *Magneticall* matter, and ſome without, as alſo the entrailes, and interiour ſubſtance, barke or ſcarfe of the earth, conſiſting of a great quantity of ſubſtance not *Magneticall*, whereupon it commeth to paſſe, that when the *Magneticall* faculty of the earth ſhall direct theſe *Magneticall* inſtruments of the Needle and Compaſſe, they are not compoſed or ſet directly vpon the true Meridian that paſſeth right on to the poles of the earth, but are drawne and forced awry towards ſome vigorous and *Magneticall* eminency of the earth, whereby the Meridian which the Needle and Compaſſe maketh doth decline and vary from the true Meridian of the earth, certaine parts & degrees in the Horizontal circle, which is called the variation of the Compaſſe; the Meridian that this declinatiō of the compaſſe & needle maketh, may be termed the *Magneticall* Meridian, to diſtinguiſh it from the true Meridian, and the ſpace betweene the *Magneticall* Meridian, and the true Meridian is the difference of variation; So that here the needle & Cōpaſſe do diſpoſe themſelues into the North and South obliquely, and not truely and exactly, and according to the diuerſity and ſtrength of the ſcattered *Magneticall* bodies, being the cauſes of variation, the arch of the declination is greater and leſſer, as in ſayling by great Continents, and High-lands *Magneticall*, either the point or taile of the Needle, and Compaſſe, is forced.

ced awry towards the Eaſt or Weſt, as is demonſtrated in the chapter of Applications, & in the XXIII. Chapter.

For if the *Magneticall* eminency, whether it bee iron like clay, myne of iron, or rocke of *Load-ſtone*, be contiguous vnto the *Magneticall* Globe of the earth and faſtened in the ſame ſubſtance vnto it, then the Compaſſe and Needle will leaue the direction of the *Magneticall* Globe of the earth, and deflect towardes this eminency, but if this Mountaine *Magneticall* be not continued with the Globe, and haue other Materials vnder and about him, then the Needle and Compaſſe will be thruſt awry, and flye from it, declining as much, in a maner, the other way, leaning vnto it by the other point or taile, as it is demonſtrated in the rule of Application of one Needle, in his varrying vpon the *Load-ſtone*, vnto a peece of Iron, touching and not touching the ſtone.

And no leſſe doth the Needle and Compaſſe vpon the continent and inner-land, decline Eaſterly or Weſterly, when as a great part of the earth ſhall bee of a ſubſtance no way *Magneticall*, and the other part ſhall bee of a vigorous and Adamantine quality to attract vnto it.

For although all direction to the North and South by the Needle and Compaſſe, be from the vertue of the whole *Magneticall* Globe of the earth, yet a ſtrong effectuall, and neere perticular cauſe, though weaker, as it is proued in the end of the XXIII. Chapter, varieth their direction diuerſly, and erratically, by that Land eſpecially which lyeth and treateth North and South.

Where as the vigor and potency *Magneticall* increaſeth from the Equinoctiall to the poles of the *Magneticall* Globe of the earth, as it doth in the *Terrella*, whereby the like eminency *Magneticall*, in the parts neere the poles, be of more allicient and Adamantine property, then they are about the Equinoctiall, therefore it may bee thought, that in ſayling vpon one Meridian, in like diſtance, from this eminency, enriched with this vigour, it will make a greater variation of the Compaſſe neere the pole, then it doth neere the Equinoctiall, but this matter may bee helped and leſſened by the great vigour that the needle is directed withall from the Adamantine Globe of the earth, eſpecially if the Seas bee ſhallow, and the Needle in a neere Orbe vnto the ſame, for thus the Needle will very hardly bee remoued, becauſe the force of the earth is great that directeth it, but marke that in the XXIII. chapter, where a ſmaller ſtrength *Magneticall* altereth quickely the retention of the whole more vigorous *Magnet*.

Alſo it is thought, that the variation of the compaſſe is much furthered by the naturall inclination of the needle and his conformity to an high-land, along the Meridian, betweene the æquator and the pole, like the demonſtration of the *Tab. VII. Fig.* 2. where the long *Load-ſtone* varieth the Needle from the Meridian by little and little to a right angle, ſo if it could bee found out, that a neere perticular cauſe were ſo potent to vary the needle, as the long-ſtone, there is the ſide of the land would vary much, but the cap farre more, alſo at the æquator, as in the *Tab. VIII. Fi.* 5. an eminent part of land, ending at the æquator, might vary the needle much, as is there demonſtrated.

Although theſe applications be great inducements that there ſhould be ſuch poſitions of the Compaſſe, in ſome places betweene vigorous lands, to be obſerued, yet becauſe that theſe eminences from land, are not any particular and complete *Magnets* of themſelues, but adherences and protuberances of ſome part of the *Magneticall* Globe, and haue their nature according to the vigour of that paralell where they ſtand, and haue not euery one of them a pole neere their caps and angles, as theſe *Magnets* haue, in their demonſtrations ſet downe. I cannot wholy approue them for ſufficient demonſtrations of variation, though they may helpe very much for the vnderſtanding of the ſame.

Therefore, for the better knowledge of the variation of the Compaſſe by the *Terrella*, it is very conuenient to apply a ſtrong *Magneticall* body vpon the *Terrella*, alongſt the Meridian, or a little obliquely, then carrying a little needle vpon the *Terrella*, the needle will vary more from the true meridian neere the æquator, then it will doe neere the pole, becauſe the Needle neere the pole is directed very ſtrongly and ſtiffely by thoſe parts, and will hardly bee forced from his direction.

But let the eminency bee very vigorous thicke, and about twenty degrees high, then hold the Needle ſo high from the *Terrella* in that Orbe, then the Needle is to be conueyed from the æquator to the pole, and firſt bring this eminence towards the Needle, and it will beginne to vary from his direction, being within twenty degrees or parts of the eminency, and ſo increaſe his declination continually till hee bee varied towards ſixty degrees, in the parts neere the æquator, and about fifty degrees, at the moſt, in the parts neerer the pole in the ſame Orbe, therefore the deeper that the Seas are, the greater is the *Magneticall* Orbe, and the more ſubiect to ſuffer the Needle to bee attracted by a neere eminency, and the ſhallower that the Sea is, the leſſe is the *Magneticall* orbe of the earth, which more hardly ſuffereth the Compaſſe to vary.

This is to bee noted that high-eminences and lands neere the poles, being before the Compaſſe doe not cauſe the ſame to decline, but onely ſuch eminences as are placed according to the Meridians, and trent North and South, or obliquely a little on either ſide, to theſe the Compaſſe will be attracted awry from his true direction.

But if there be a narrow paſſage betweene two highlands, then the Compaſſe and Needle will reſpect neither eminency, but carry and direct it ſelfe paralelly betweene them both, when the ſtrength of two highlands is of equall force; as it is demonſtrated vpon the *Terrella*, and not vnlike to the figure, *Tab. VIII. Fig.* 3.

This is to be obſerued alſo, that the middeſt of an high-land, by demonſtration vpon the *Terrella*, doth attract moſt, and make the greateſt variation, and towards the ends it decreaſeth by little and little, and once paſſing by the eminency it varieth the compaſſe no more, and it is likely ſo to do vpon the earth.

If there be a *Magneticall* rocke lying ſidelings vnder the water, it will make the needle vary a little from the true Meridian.

Therefore the farther that the Compaſſe is diſtant from an high-land, that attracteth, the leſſe is the variation, and paſſing further out of the orbe of his vertue there will be no variation at all, vnleſſe the deepes and ſubſtance of the earth bee partly *Magneticall*, and partly of different ſubſtance, For theſe cauſes it is obſerued, that places of a ſmall diſtance aſſunder do differ much in their variation, holding one proportion, neither in paſſing vpon a meridian, or on a paralell, yet in one and the ſelfe-ſame place variations neuer differ, but remaine certaine and conſtant.

The Weſt-ſhore of a *magneticall* continent doth make the variation of the compaſſe Eaſterly, and the Eaſt-ſhore of a maine-land beholding the Sunne riſing attracteth on the North-ſide of the æquator, the Lilly of the Compaſſe that it decline Weſt from the true Meridian, on the South-ſide of the Equinoctiall the point of the Needle is attracted, *Table XIII. Fig.* 1.2.

About the Ilands of *Azores* the Compaſſe hath litle variation, as at *Fayall* the Compaſſe varieth to the Eaſt three degres, and at *Coruo* the variation of the Compaſſe foure degrees to the Weſt.

Some thinke that Ilands, though *Magneticall*, make no variation, being too weake and feeble in regard of the great ſtrength of the directiue globe of the earth, which directeth the needle and compaſſe, becauſe that the Iland of *Elba*, neere *Florence*, being ful of *Loadſtones*, cauſeth no variation of the compaſſe more then other places neere adioyning do, but if vpon the *Terrella*, as in the XXIII. chapter there be neuer ſo litle wiers applied neere a needle, it will deflect towards them, ſo that here perfect obſeruation may be deſired, which by the common rules is long and tedious to performe: therefore I will ſet downe ready and eaſie wayes to obſerue the true meridian by the Sunne, that the variation of the compaſſe may be plainely perceiued, and that in a moment, by one obſeruation only, to the end that induſtrious and skilfull pilots will in time furniſh themſelues and the world with the true obſeruation of variations in all parts of the world.

CHAP. XXVII.

Of finding the variation of the Compaſſe by one obſeruation.

For this purpoſe there are certaine things to be knowne, and obſeruations to be had in a readineſſe before this concluſion be found out, firſt the place is to be ſet downe by name or note, where this obſeruation is made; then the altitude of the pole in that place is to be knowne and ſet downe, after the day of the moneth; and the declination of the Sunne are to be ſet downe, all theſe things skilfull pylots know very well to performe. Then hauing a good ſea-compaſſe for the water, and a large directory-needle for the land, it is neceſſary vpon the outmoſt part and circle of theſe to haue a limbe or verge a quarter of an inch broad for the horizontall circle, and to haue the one halfe of it deuided into two ninties of degrees, with his conuenient parts and figures, as is vſuall in all quadrants, beginning the numbers from the meridian-line, and ending them at Eaſt and Weſt.

Next prouide a diamiter ſomewhat longer, then that of the circle, of braſſe, wier, or ſiluer, hauing in the middeſt or center of it a ſmall wier of the ſame mettall, faſtened and ſoudred vnto it at right angles, as a *Semidiamiter*, all this being framed will be like in faſhion to the beame and tongue of the ballance of a paire of ſcales, *Tab. XIII. Fig.* 3. and iuſt at the Eaſt and Weſt put this diamiter through two holes of the ſides of the compaſſe, or faſten it there with two loopes of braſſe, that you may turne the ſemidiamiter vp and downe iuſt ouer the center of the compaſſe and needle, and this may be ſet vpright at either end, with two little ſhoulders of braſſe to keepe the ſemidiamiter vpright aud perpendicular vnto the horizon.

Hauing the compaſſe and needle thus furniſhed, place the needle and Lilly of the compaſſe iuſt againſt the beginning of the diuiſions, then ſet the compaſſe before the Sunne, with this ſemidiamiter erected where the compaſſe and needle ſtanding in their *Magneticall* meridian, the ſhadow of the Sunne from this ſemidiamiter will ſhew vpon the degrees of the limbe the *Magneticall* poſition, and azimuth of the Sunne, which is preſently to be noted downe, as it is Eaſt or Weſt.

Note that at ſea if the ſhip turne any thing about, the boxe of the compaſſe muſt alſo be turned, that the meridian of the flie may be alwaeis againſt the beginning of the diuiſions.

Likewiſe, becauſe of the ſhips vnſteadineſſe at ſea, it is fit to haue a wier erected from the center of the flie, whoſe ſhadow among the diuiſions, vpon the flie of the compaſſe, will ſhew the *Magneticall* azimuth.

Then inſtantly hauing a *Iacobs* ſtaffe at ſea, and a quadrant at land, take the altitude of the Sunne, which is to be noted downe, and after at pleaſure and leyſure, hauing theſe petitions, the variation of the compaſſe for that place may thus be had.

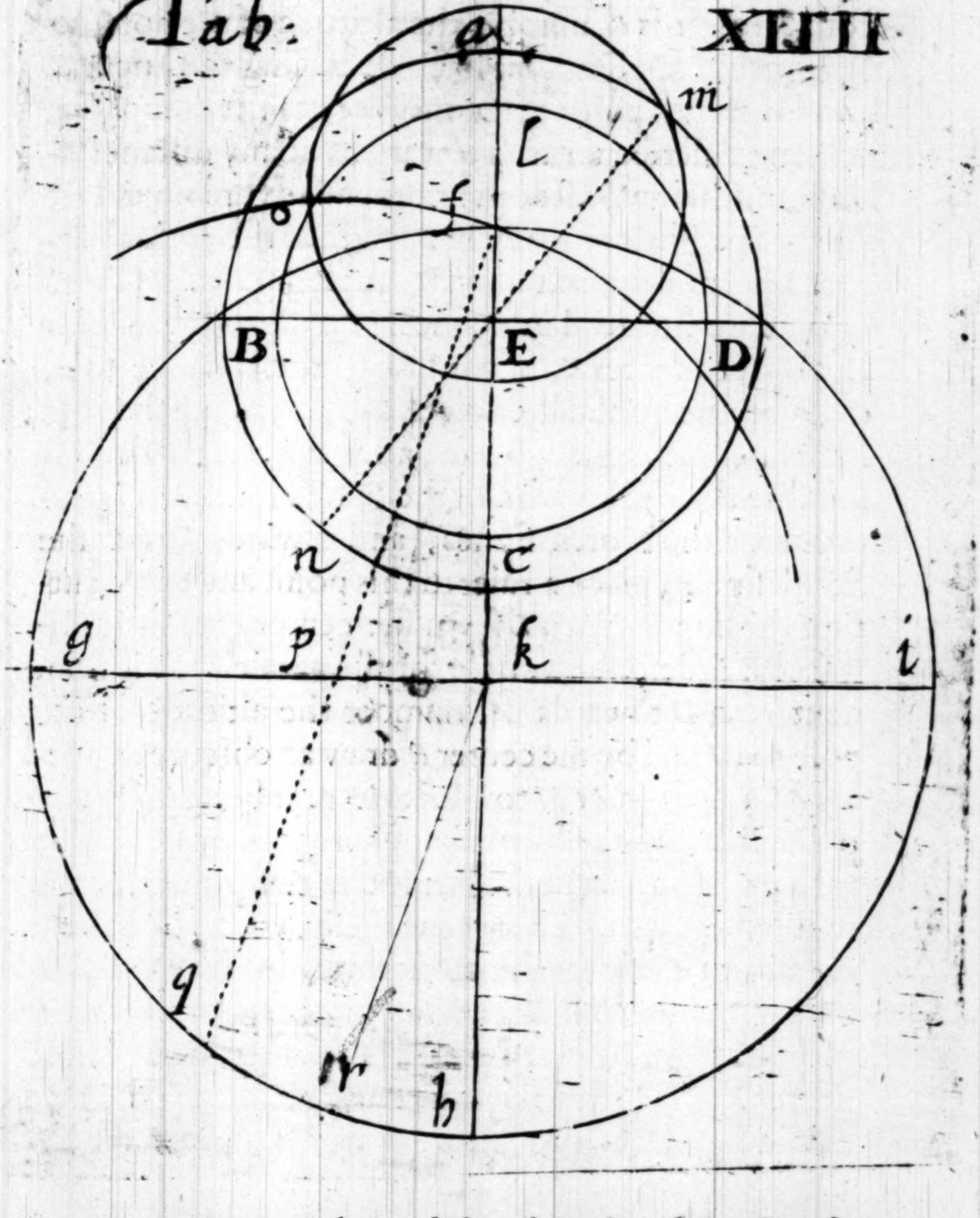
Take M. *Blagraues* Mathematicall Iewell, or the *Aſtrolabium Catholicum*, ſet out firſt by *Gemma Frigius*, which is not ſo ready as this, becauſe it lacketh the rete which this hath; place the horizon of the rete to the altitude of the pole for that place, and looke where the Sunnes altitude that was obſerued and almicantareth croſſeth and meeteth with the paralel of the Suns declination for that day before ſet downe, and the azimuth or verticall circle that croſſeth theſe two in that point where they touch, and this is the true azimuth of the Sunne from the true meridian, which differing from the *Magneticall* azimuth at firſt obſerued vpon the compaſſe, the difference of theſe two azimuths is the arch of the variation of the compaſſe, and of the *Magneticall* meridian from the true meridian, which is to be ſet downe, that this is the variation of the compaſſe towards the Eaſt or Weſt for that place.

CHAP. XXVIII.

Of finding the variation of the Compaſſe, by the circles of the Aſtrolabe.

FOr this purpoſe the petitions required in the former chapter, are to be writ down, and in a readineſſe, as the place of the obſeruation, with the altitude of the pole in that place, the day of the moneth, with the declination of the Sunne for that day, the

Tab: XLIII



Magneticall azimuth, and the altitude of the Sun for that one inſtant of obſeruation. Now in deſcribing the circles of the Aſtrolabe for this purpoſe, firſt vpon a line *B E D* at the center *E* make a circle *a B C D*, and by the center *E* draw the line *A C* at right angles to *B D* from *A* towards *B*, number the altitude of the pole, to which point apply a ruler from *D*, cutting the line *A C* into the zenith point *F*, ſet one foote of the compaſſes in *F*, and deſcribe an arch towards *B* at any diſtance aboue and below, after the compaſſes vnremoued ſet the foote of the compaſſe in *B*, and cut the former arches into points, vnto which applying a ruler, draw an obſcure line to deuide the line *A C* produced into *K*, from the center *K*, according to the diſtance to *F*, deſcribe the verticall circle *F G H I*, making the line *K G I* at right angles to *F H*, now from *A* towards *B* number the declination of the Sunne for the day propoſed for the North ſignes, and towards *D* for the South ſignes, place a ruler to this point and to *D*, cutting the line *A E* into *L* from the center *E*, as is the diſtance *E L*, deſcribe a circle for the paralell of the Sun, next from *D* towards *A*, number the altitude of the pole to *M* and by the center *E* draw an obſcure diameter *M, E, N* from *M N* towards *A B* number the altitude of the Sun before obſerued, applying a ruler from *D* to each deuiſion, to cut the line *A C* in two points frõ the middeſt, as a center betweene theſe two, and by them deſcribe a circle for the almicantarath of the Sun, deuiding the paralell of the Sunne at *O*, from *O* and *F* make obſcure arches to cut one the other, from whoſe center *P* to *O F*, deſcribe an arch of a circle for the true azimuth. Which to know what it is, draw an obſcure line from *F* by *P*, to the circle *F G H I* vnto *q*, then deuide the arch *q h* in the middeſt at *r*, and the arch *g r* reſolued into degrees, ſhall be the diſtance of the true azimuth from the meridian. The difference of the *Magneticall* azimuth from this azimuth, ſheweth the diſtance of the meridian of the compaſſe from the true meridian, which diſtance is the variation of the compaſſe for the place obſerued.

A ſhort way vpon land to draw the meridian line vpon a plaine ſuperficies leuelled to the horizon; immediatly before the obſeruing of the altitude of the Sun, hold a plummet by a thred, that the ſhadow light on this ſuperficies, in this ſhadow make two prickes to be ioyned together in a ſtraight line, after out of this type ſet the angle *g k r*, which ſhall be the meridian from the line of the azimuth made by the ſhadow.

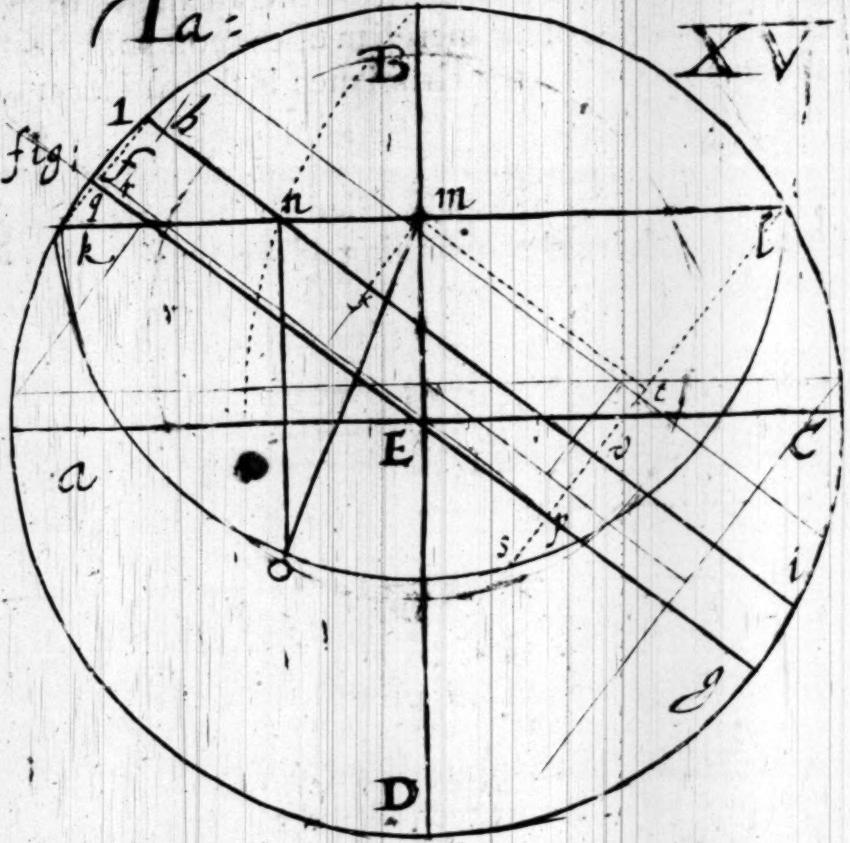
CHAP. XXIX.

Of finding the variation by the Analemma.

BEeing furniſhed with the petitions, before recited in the former chapters, make this Analemma, about the horizontall line *A E C*, deſcribe a meridian circle, and make the verticall diamiter *B D* by *E*, at right angles to *A C*, then from *A* to *F* in the quadrant *A B*, number the complement of the altitude of the pole, and by *E* draw a line *F G* for the interſection of the æquator & meridian, thē number from this æquator on both ſides the declination of the Sun for the day of obſeruing, being 10 degrees, and from the points draw the line *H I* for the paralell of the Sunne, next in either quadrant aboue the line *A C*, number the altitude of the Sunne before obſerued to be 30, to *k* and *l* ioyne theſe two

Ta: XV

fig: 1



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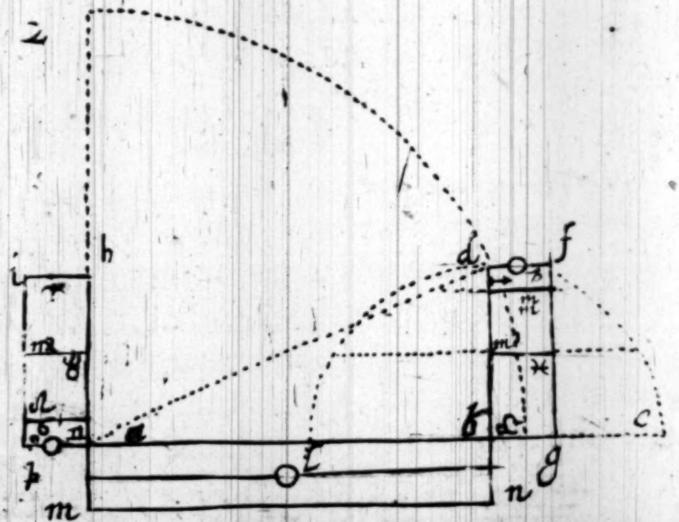


together in a line paralell to *AC* the horizon, paſſing through the center of the Sunne, and cutting the verticall line *BD* into *M*, and the paralell of the declination of the Sunne *HI* into *N* from *M* a center, deſcribe a ſemicircle to *kl*, and from *n* draw a perpendicular line with *kl* vnto this ſemicircle, deuiding the ſame in *O*, and ioyne *mO* by a line together for the diſtance of the azimuth from the true meridian, which being reſolued into degrees, and compared with the *Magneticall* azimuth, the difference betweene theſe azimuths ſheweth the degrees of the variation of the compaſſe.

CHAP. XXX.

Of finding the variation of the Compaſſe by an Equinoctiall Diall.

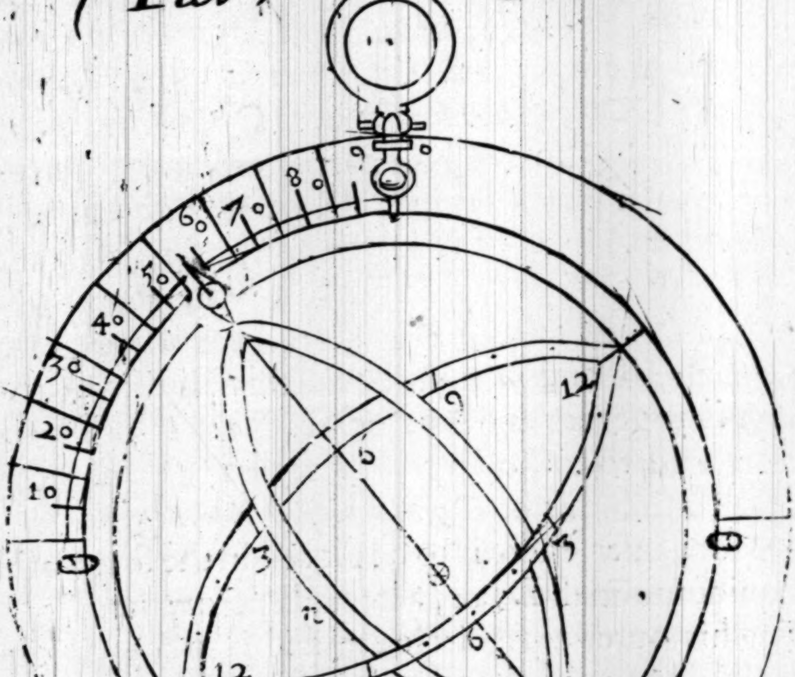
PRouide in a readineſſe, an vniuerſall Equinoctiall Dyall vpon a plaine, that may artificially be erected to the height of the complement of the Latitude of the pole, for the place of obſeruation, and vpon the center of the Equinoctiall-circle place a ruler, and at eitheir end of the ruler erect a plate of braſſe, little more then a quarter of an inch broad, that may with iointes conueniently bee raiſed at right angles, to the ruler and ſuperficies of the Dyall, and vpon theſe plates place the diuiſions of the Trigon of the twelue ſignes, after this manner. *Tab. XV. Fig. 2.*

Draw a ſtraight line *a b*, and from *a* center, deſcribe *a* quadrant of a circle to *c*, and let *c a* cut *a b* at right angles, then deuide the quadrant *c b* into ninty degrees, then from *b* towards *c* number the greateſt declination of the Sunne, which is 23 degrees and an halfe, ending in *d*, and at *d* draw a line at right angles, to *a b*, which is *d b*, and ſet the length of the line *d b* from *a* to *h* in the line *a c*, then produce the line *a b*, obſcurely to *e*, and from *b* as a center according vnto the diſtance *b d*, make an obſcure ſemicircle ouer the line *a b e*, deuide this ſemicircle into ſixe parts, for ſixe ſignes, euery diuiſion containing 30 degrees, when it ſhall bee ſub-deuided then ioyne theſe diuiſions together in paralell lines to *a b e*, for the beginning of the ſixe South-ſignes, then from *d b* draw a paralell line *f g*, according to the bredth of the plate, and from *d* to *f* make a paralell to *a b e* in *d f*, the plate being ſome-what higher, make an hole, as in a Diopter, that the Sunne may ſhine in at it in Summer time, vpon the other plate at *a h* for the North-ſignes, which plate *a h i k*, would bee of the ſame bredth and height that *b d*, *f g* is, then let the obſcure paralell lines of the beginning of the South ſignes bee drawne vpon this plate, place ♎ *Libra* aboue the line *b g*, ♏ *Scorpio* aboue next line, ♐ *Sagitary* aboue the next line, and vnder the line *d f* place ♑ *Capricornus*, vnder the next ♒ *Aquarius*, and vnder the next ♓ *Piſcis*, the other plate for the North-ſignes, muſt haue the ſame paralell lines in it that this hath, for the beginning of the North-ſignes, and an hole in it for the Diopter, that the Sunne may paſſe through it to the firſt plate of the winter-ſignes to ſhew them that part of the plate or end that hath the Diopter in it is to bee placed in the line *b a k*, contrary to the ſituation of the paralels in the firſt plate, & vnder the vpper-moſt line *h i*, place ♈ *Aries*, vnder the next ♉ *Taurus*, vnder the next ♊ *Gemeni*, then aboue that line that hath the Diopter, in it place ♋ *Cancer*, aboue the next ♌ *Leo*, and aboue the next ♍ *Virgo*, ſo is all the characters of the ſignes placed in their plates, let the ruler be of the bredth of the plates, and in the middeſt of it draw a line, and in the middle of it make a hole of the center *L*, the better to bee faſtened to the center of the Equinoctiall: *k* and *m* muſt bee artificially ioyned with ioynts together and *g n*, at which the ruler from *l* is produced to make an *Index* vpon the Equinoctiall-dyall to ſhew his howre as it is *Tab.XV.Fig.*2.

More-ouer, there is to be placed in the foote of this Equiquinoctiall Dyall, a large directory-needle, hauing his outer-moſt circle diuided into foure ninties, beginning to number the parts from the Meridian to the Eaſt or Weſt.

This Equinoctiall Dyall being thus furniſhed with the ruler and plates for the Zodiake and the directory-needle, and erected to the Equinoctiall of the place, where the obſeruation is made, turne the whole frame of the Dyall and ruler about with his plates, vntill the Suune-ſhine directly vpon the ſigne and parts that he is in for that day, then his whole frame will ſtand in the true meridian, and the directory-needle will ſtand in his *Magneticall* meridian, and point out ſo many parts in his horizontall circle, as his variation in that place is to the Eaſt or Weſt, which is to bee noted downe, and the ruler in the Equinoctial circle ſheweth the true hower and part of the Sun, for that day and inſtant.

Tab: XVI.



CHAP. XXXI.

Of finding the variation of the Compaſſe by Rings.

There is an other inſtrument conſiſting of foure ringes of Braſſe, one to bee placed within the other, which is an vniuerſall Dyall, hauing a directory-needle in a boxe, faſtened at the bottome of the ſame, which doth ſhew likewiſe preſently the variation of the compaſſe hanging perpendicularly, *Tab.XVI.*

The firſt two rings of this inſtrument are two meridians, the outer-moſt is broad, and hath a ring to hold it by, faſtening it to the vpper end or top, and the North-quadrant towards the ring or handle is diuided into ninty degrees for the numbers of the altitude of the pole, alſo this ring hath faſtened vnto it at the bottome a directory-needle in his boxe, the limbe whereof is diuided into two ninties from the meridian to the Eaſt and Weſt.

Within the ring of this broad meridian, there is an other meridian-ring placed, ſo kept in on the ſides, that it may bee moued higher or lower, ſo that his broad *Index*, faſtened vnto one of the foure quadrants, may bee ſet to point out the degrees of the altitude of the pole, this *Index* hath a lower end for to ſtay the fourth ring that carrieth the Trigon of the ſignes, and a thred like an *axis* with a moueable beade thereon.

The third ring within the ſecond is for the Equinoctiall circle, and it is faſtened to the moueable Meridian-ring at right angles to the eleuation of the pole by two pinnes, whereon it may bee moued at right angles to the meridian, though it will be laid within the ſaid meridian, in the inner part of this ring there is a circle to bee drawne for the Equinoctiall circle, and to bee diuided into 24 parts, for the howres of the day, from the meridian; and ſub-diuided with conuenient lines and figures.

The fourth ring is fitted within this Equinoctiall ring, and at ſixe of the clocke, or at the Eaſt and Weſt is faſtned to it with two pinnes, to moue at right angles vnto the ſame, this carrieth an *axis* which being moued about is ſtayed by the nether end of the moueable meridians *index*, deſcending into a nicke in it to hold it at right angles with the æquinoctiall-circle in manner of a ſphere, and holdeth the ſaid circle at right angles with the meridian, within this fourth ring, whoſe *axis* is ſtayed by the *Index* from either ſide of the æquinoctiall, hauing the center in the æquinoctiall at the ſide of the ring, there is deſcribed aboue it, and below it, the greateſt declination of the Sunne, and the arch betweene the ſame and the æquinoctiall is diuided into ſuch parts for the beginning of the twelue ſignes as the plates before were in the former chapter, adding the characters of the twelue ſignes, as it was there done; then at the ſides of this ring in the æquinoctiall where the center of the fore-ſaid declination was taken, faſten the head of a pin of braſſe, and from it beholding the ſigne & place on the other ſide that the Sun is in that day, and betweene the eye and that place in this line place the beade vpon the *axis* and ſo fixe it.

Now hauing this inſtrument thus prepared, ſet the *Index* of the moueable meridian vnto the altitude of the pole, and mouing the Equinoctiall circle, and the colure-circle or different of the ſignes, and faſten it firme at the lower end of the *Index*, hold the inſtrument by the ring, or handle, like a ſphere perpendicularly, and turne it too and fro till the ſhadow of the bead light vpon the middle line of the æquinoctiall-ring, thus the meridian of this inſtrument ſtandeth vpon the true meridian, the ſhadow of the beade ſheweth the howre and his part of the day, & the needle in the boxe pointeth out the variation of the compaſſe in the limbe of the horizontall circle.

Theſe rings, at pleaſure, may bee folded one with in the other for conueniency of cariage, and in time of vſe ſet abroad like a ſphere.

Any vniuerſall, or Aſtronomers ring, would bee of eſpeciall vſe for the finding of the true meridian, as well as theſe, and hauing the needle added vnto them, the variation of the compaſſe would be found.

CHAP. XXXII.

Of finding the variation of the Compaſſe by an Horizontall Dyall.

WHen I was a yong ſtudent in the Vniuerſity and delighted in making of Dyals, I was alwaies wont to place the lines of the twelue ſignes in them, that when I ſet any bodies of Dyals in the Sunne, vpon a leuell foot, I alwaies directed them by the ſhadow of the Sunne vpon his ſigne and part into the true meridian and South, and hauing a large horizontall Dyall for any Region, with the lines of the twelue ſignes deſcribed in it, placing the ſame vpon a leuell plat-forme, and turning it vntill the nicke of the ſhadow of the ſtile light vpon the place and ſigne that the Sunne was in for that day, then fixing a compaſſe or needle with his meridan paralell to the meridian of the Dyall, the needle will ſhew in the limbe of the horizontall circle the variation of the compaſſe, and the Dyall ſheweth the howre and his part of the day.

This Dyall might bee made vniuerſall as well as the æquinoctiall, if that in trauelling North the North ſide were eleuated by meanes of a quadrant, that the plaine of the Dyall might alwaies haue the pole of the Dyall erected aboue him to that latitude for which it was deſcribed, and in paſſing Southerly the South-ſide of the Dyall would bee ſituated by the quadrant to his propper eleuation.

And if that the Azimuths and Almicantars were put into this Dyall, then the Azimuth and altitude of the Sunne, with the place of the Sunne and howre, would be preſently ſhewed by the ſhadow of the ſtile, ſo that for theſe purpoſes, this horizontall Dyall would bee made vniuerſall, as a generall Aſtrolabe or Aſtronomicall ring.

CHAP.

CHAP. XXXIII.

Of finding the variation in degrees and minutes by the doctrine of Triangles.

WHereas many may be deſirous to know preciſely the degree & minutes of the variation of the compaſſe, for to ſatiſfie theſe mens appetite, it is very conuenient to vnderſtand the doctrine of Triangles, for by the Tables of ſines, Secants, and Tangents, with the Axiomes and conſequents, & the Golden rule this, matter wil be attained vnto. And therefore for this purpoſe, I would aduiſe you to obſerue and marke the frame of the Analemma ſet downe before in the XXVIII. chapter, *Table XV. Fig.* 1. with the obſcure lines pricked therein.

Firſt in this Analemma let *GC* equall to *AF* bee the eleuation of the æquinoctiall line, conſiſting of 38 and an halfe, which being called to *CL* 30. the Sunnes altitude at the inſtance of obſeruation for that day, and the ſome of theſe will bee 68. ½ whoſe Sine is the obſcure pricked line *LP*, now take *AK* 30. degrees being the Sunnes altitude, out of *AF* the æquinoctiall Altitude 38. ½ there reſteth *Kf* 8 ½, whoſe ſine is the obſcure line pricked *qK*, which added to *LP*. produced make *LPS*, 77.

Diuide *SL* into two equall parts ending in *t*, and take from *St*, being 38 ½ the ſine of the Sunnes altitude *K q* 8; and take alſo out *h r* being 10, the ſigne of the Sunnes declination, and there will remaine *t V* being 20, then ioyne *t* and *m* together in an obſcure pricked line, and make a line at right angles to this from *m* to *x* being 20, and is equall vnto *t V*, ſo haue you this demonſtration, and if you looke into the Table of ſines for the numbers, you ſhall finde them ſet downe in their place.

And as the ſine of *t l* is vnto the ſine of *l m*, ſo is the ſine of *x m* vnto the ſine *m n*.

So that the angle *M B* K in the Analemma being the complement of the angle *M B N*, will be the Azimuth you ſought for, and it is equall to the angle *O m D* in the ſaid type, which compared with the *Magneticall* Azimuth, the difference betweene them ſheweth what the variation is from the true meridian.

Secondly, it is to bee noted, that if this obſeruation, or taking of the Sunnes altitude be before 6 a clocke in the morning, or after at night, when the Sunne is in the North paralels, that *N* the interſection of the Sunnes altitude and paralell of the Sunnes declination bee on the ſame ſide of the Analemma that *t* is on, then take *h r* the ſine of the Suns declination out of *l t*, and there will reſt *t V*, ioyne *t* and *m* together, and make a ſmall line at right angles from *n* to *x*, equall to *t V*, for as *t l* is to *k m*, ſo is *x n* vnto *n m*, &c.

Thridly, and laſtly, if obſeruation bee made when the Sun is in the æquinoctiall, then make the ſmal line *m x* equall to *P t*, and looke what proportion *t l* hath vnto *l m*, the ſame hath *x m* to *m n* where *n* is on the æquinoctiall line, *&c.*

CHAP.

CHAP. XXXIIII.

Of the application of the Inclinatory-needle to the axis of the Earth.

WE haue ſhewed how the compaſſe and directory-needle do apply and order themſelues in the *Magneticall* meridian towards the pole, and of the correcting of his erring from the true meridian and pole, being caried leuell and paralell to the horizon, and ſeated in any part of the terreſtriall globe, whereby, and to the end the traueller by ſea and land may take his courſe certainely, to any coaſt or part of the world. Now it remaineth that we treate of the vſe of another needle, called the *Inclinatory-needle*, which being artificially placed in his ring, is as profitable to all Nauigators and trauellers, as that formerly ſpoken of; for by this they may know the eleuation of the pole in all parts of the world without the ſight of the celeſtiall globes and lights.

This *Inclinatory-needle* fitted in his ring, and placed in the *Magneticall* meridian, doth apply & conforme it ſelfe vnto the *axis* of the *Magneticall* globe of the Earth (whereas the directory-needle doth apply vnto the meridian and pole) and that diuerſly in diuerſe eleuations of the pole, for ſailing vpon the æquinoctiall of the earth, this *Inclinatory-needle* maketh a paralell-line with the *axis* of the earth, being vpon the pole, this needle will make one continued line and *axis* with the *axis* of the earth: paſſing from the æquinoctiall to either pole, this *Inclinatory-needle* will conforme it ſelfe vnto certaine acute angles with the *axis* of the earth, which increaſe from the æquinoctiall in largeneſſe, and proue leſſe acute in euery paralell, ſo that the angle of the earths *axis*, and the *axis* of the needle is at the greateſt about 42 degrees of the poles eleuation, and the difference betweene theſe two will be neere 22 degrees and a halfe, being here at the largeſt, after it decreaſeth continually towards the pole, where the needle will ſtand directly vpon the *axis* of the earth.

Now to know and find out this angle what it is, it is neceſſary to learne what angle this *Inclinatory-needle* maketh with the horizon in euery latitude of the pole, becauſe if the eleuation of the pole be taken out of this angle with the horizon, which is alwayes the larger, (vnleſſe it be at the æquinoctiall and the pole) and hath the *axis* of the earth alwayes betweene him and the horizon, the remainder is the angle of this needles conformity with the *axis* of the earth.

Therefore we will leaue to ſpeake of the *Inclinatory-needles* moſt naturall and true conformity with the *axis* of the earth, and hereafter ſhall deliuer by what meanes the angle betweene the *Inclinatory-needle* and the horizon may be knowne, to the end that the eleuation of the pole may thereby be found out.

CHAP.

CHAP. XXXV.

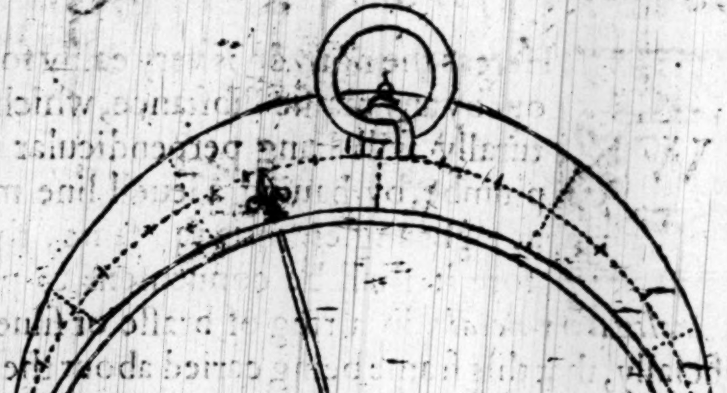
Of the Inclinatory Ring and Needle.

WHereas the horizon is very eaſily found out by any maſſie ſubſtance, which naturally will hang perpendicular and plumbe, by hauing a leuell line made at right angles vnto the ſame, therefore it ſhall be conuenient to place this *Inclinatory-needle* in a ring of braſſe or ſiluer, ſo artificially, that this frame being caried about the meridian of the earth, this needle may make all kind of acute angles with the horizon in the varieties of his inclinations vnto him, as at the æquinoctiall this needle lieth leuell with the horizon, ſo at the pole it ſtandeth at right angles to the horizon, and directeth it ſelfe in one line with the *axis* of the earth, and paſſing from the æquinoctiall, it doth eleuate it ſelfe aboue the horizon twiſe as faſt as the pole doth, vntill the pole haue about an 11 degrees of latitude aboue the horizon, but after the needle ſlacketh his pace by little and little, vntill he come to the pole where both ioyne together without any angle at all in one line directly.

Alſo this needle maketh alwayes one kind of angle with the horizon in one paralell and altitude of the pole, and a diuerſe arch from the ſame, but one certaine in one latitude, as by this inſtrument following ſhall appeare, and euery where be obſerued.

Take a long peece of ſteele-wier, and through the middeſt and center of the ſame put a ſhort wier thorough

Tab. XVII



rough this ſame *axis* at right angles exactly, or rather file a plate of ſteele artificially into the forme of the *Inclinatory-needle* with his croſſe *axis*, as you ſee in this type, *Tab*, *XVII*, *Fig*. 1. and *Tab. II*, *Fig*. 16. and at right angles together. Then prouide a round ring of braſſe or ſiluer, perfectly poliſhed and rounded, of the breadth of an inch and a quarter, almoſt as broad as the ſhort *axis* is in length, hauing a little ring, in the top to hold it perpendicularly, as in this type. This ring muſt haue within it another plate and ring cloſe faſtened vnto it, but let it be ſomewhat narrower, and draw in the middeſt of it a middle circle for the meridian circle, which is to be deuided into foure nineties, beginning from the ſides, and ending the deuiſions, and their numbers in the top and at the bottome.

After prouide two narrow plates of braſſe or ſiluer, to be faſtened on either ſide of the ring paralelly to the horizon, and in the middeſt of theſe, as it were, againſt the center of the ring, drill and make two little holes almoſt through the ſides of the plates for the ſhort *axis* of the *Inclinatory-needle* to play and moue in, vp and downe, according vnto this kind of *Magneticall* and *Inclinatory* conformity. Laſtly, this inſtrument would be couered with two glaſſes for both ſides to keepe the *Inclinatory-needle* from wind and weather, and a care had that the inſtrument hang truly perpendicular.

In time of vſe in trauelling, hang this inſtrument South and North in the *Magneticall* meridian, and this *Inclinatory-needle* will fall with one end vnder the horizon in euery eleuation of the pole, and beare vp his other end in euery paralell and altitude of the pole to a certaine angle with the horizon, which may be called the Inclinatory angle for that place, which being noted in the meridian of this ring, with the degrees he pointeth at, is to be reſerued as proportionable to that eleuation of the pole where the obſeruation is made, this matter was demonſtrated by the round *Load-ſtone* in euery part in the XIII. chapter before, which being collected by the ſayd demonſtration and practiſe, are to be placed in their correſpondency in a Table for the altitude of the pole, wherby in all places it may be had readily what will be the angle of the *Inclinatory-needle*, and what is the latitude of the pole, cauſed onely by the diſpoſition of the *Magneticall* globe of the earth, and alſo by the diagrams following it is ſhewed.

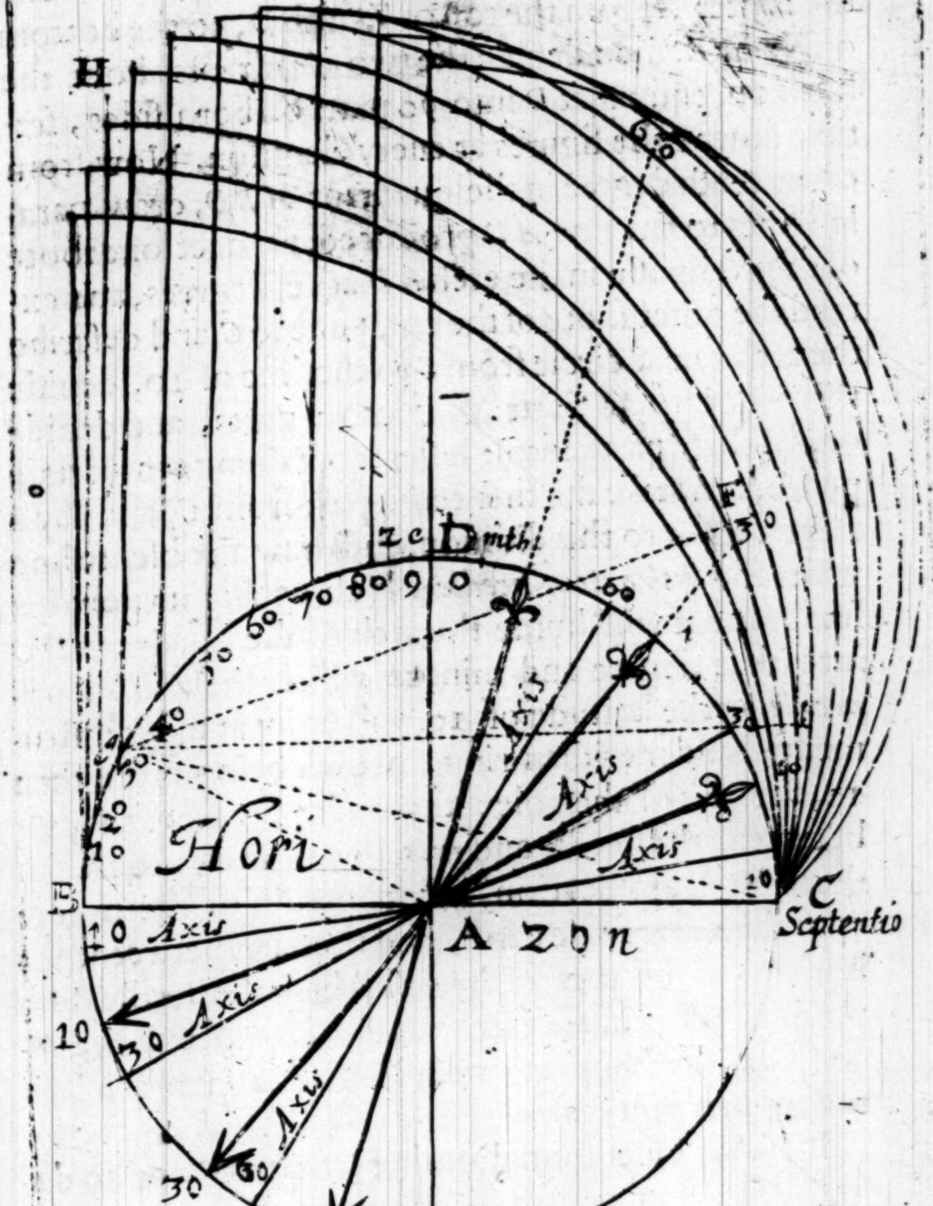
CHAP. XXXVI.

A Diagram of the needles inclinations to the axis of the earth, and horizon in any latitude.

THis demonſtration ſheweth moſt manifeſtly vnto our eyes, both what angle the *Inclinatory-needle* maketh to the *axis* of the world, or earth, in all regions, and alſo what angle or arch he pointeth at aboue or vnder from the horizon in any latitude of the pole whatſoeuer, hereby moſt euidently ſetting out the meanings of the two former chapters, and of the XIII. chapter before them, where it is demonſtrated from the ſtone it ſelfe, that this *Inclinatory-needle* will make but one circumuolution about the meridian of the earth, as it doth about the *Loadſtone*, the Diagram is this.

From the center *A* in the horizontall line *BC*, deſcribe

Tab. XVIII.


H
60
F
30
z e D nith
90 80 70 60 50 40 30 20 10
60
30
20
Axis
Axis
Axis
Axis
Hori
B
A zon
C
Septentrio
10 Axis
10
30 Axis
30
60
30
60
Axis
E.
nadir

ſcribe a meridian circle, like that in the *Inclinatory-ring*, drawing a perpendicular line croſſe the ſame by the center *A*, from the top or Zenith *D*, to the bottom or Nadir *E*, then deuide the two quadrants aboue the horizon, ending at *D* into 90 parts on both ſides, ſetting downe the figures at euery deuiſion. Now from euery tenth degree in the quadrant *A B D*, draw paralell lines to the line *A D* produced, then ſet one foote of the compaſſe in the arch *B D* at 10 degrees, and extend the other foote of the compaſſe to *C*, and deſcribe the arche of a circle from *C* to the line of 10, deuide this arch into 90 parts, firſt into 3 parts, and deuide one of theſe parts into 3 leſſer, containing ten parts a peece, now take the firſt tenth part from *C*, and lay a ruler from *A* to this diuiſion, and draw an obſcure line vnder the *Inclinatory-needle* which will light vpon this line, and it will diuide the arch of the quadrant *D C* into that degree and minute which the *Inclinatory-needle*, in the latitude of 10, will point at in his inſtrumentall and meridian-ring, which being more then 10, the *axis* of the pole, the ouer-plus from the *axis* betweene the needle and *axis*, doth ſhew the arch of the naturall application, or inclination of the needle vnto the *axis* of the earth, and the parts betweene the horizon to this part in the arch which the needle doth point at in the quadrant, *C D* is the angle that the *Inclinatory-needle* maketh with the horizon in the latitude of ten degrees.

In like manner from the other ten partes, or 90 degrees, in the quadrant *B D* draw paralell-lines to the line *A D* produced, and from euery part as a center extending the compaſſe from the ſame to *C*, deſcribe arches from *C* to thoſe lines, diuiding them into 90.

parts a peece, and take like number of parts anſwering to theſe parts in the quadrant *C D* for the *axis* of the latitude, then draw an obſcure line from *A* to the ſame part, in theſe larger arches, and that will ſhew the angle that the *Inclinatory-needle* maketh in his inclination to the *axis* and horizon in that latitude. We haue onely for example-ſake deliniated the inclination of this needle to the *axis* and horizon, in the latitudes of 10.30.and 60. the like whereof might bee performed in euery one of the other degrees of latitude, which thing is omitted to auoide confuſion of lines.

What this angle of the inclination of the needle would bee in euery latitude of the pole, although by the Diagramme, already ſet downe, it might bee Mechanically taken out of the quadrant *C D*, as it is reduced into ninty partes. Yet I will ſet downe, how out of the cannons of Triangles, the arch from *I* to *C*, may bee exactly knowne in degrees and minutes.

In the Diagram *G*, *A*, *B* 30; the eleuation of the pole being ſet for an example, draw from *G* theſe obſcure lines, as *G F*, *G K*, *G C*, *G A*, and *A F*, the line of inclination, the content of the angle *A G C* is 15, *C G K* is 15. *K G F* is 20, ſo that the angle of the Triangle *F G* is 18, 50, and the ſumme of the oppoſite angles, which marked vpon the ſemi-circle, will bee 130 degrees, whoſe halfe is 65 degrees, the tangent whereof is 214459690, then wee finde that the line *G F* in the triangle is equall to *G C*, the *Subtenſes* of 150 degrees, the halfe or ſinus hereof is 75 degrees, whoſe parts out of the Table of ſines are 96592583, which being doubled make the ſide *G F* 193185166. The ſide *G A* hath for his parts the totall ſine 100000000, the ſumme of theſe two ſides is 293185166, and the difference of them is 93185166.

Now multiply the tangent of 65 degrees 214459690 by the difference of the ſides 93185166, and diuide the product 42891938 by the ſumme of the ſides 293185166, the quotient will bee the difference of the tangents 146296413, which taken from the parts of 65 the middle tangent 214459690, the tangent parts that remaine 68163277 giue by the Table 34 degrees 16′ 47″.

Here take 34 16′ 47″ out of 65 degrees, there reſteth 30 43′ 13, for the leſſe angle *AFG*, ſo adde 34 16′ 47″ vnto 65 degrees, and it maketh 99 16′ 47″, for *FAG* the greater angle, heereto adde 30 degrees the eleuation of the pole there amounteth 129 16″ 47″ for the angle *FAB*, which taken from the ſemicircle 180, there remaineth 50 43′ 13″ for *FAC* the inclination of the needle vnto the horizon where the pole is eleuated 30 degrees.

I haue heere ſet downe a Table calculated out of this diagramme of the degrees and minutes of the angles of the *Inclinatory-needle*, with the horizon anſwerable to euery eleuation of the pole, by M^{r}. *Brigges* the Geometry reader in *Greſham* Colledge, who hath farre more ready and eaſy waies to make the fore-ſaid Table, then I haue ſet downe vnto thee, and I thinke that this Table will agree more truely with the motion from the ſtone it ſelfe then that which is made by the ſame man out of the diagramme in the Chapters following.

TABLE.

TABLE.

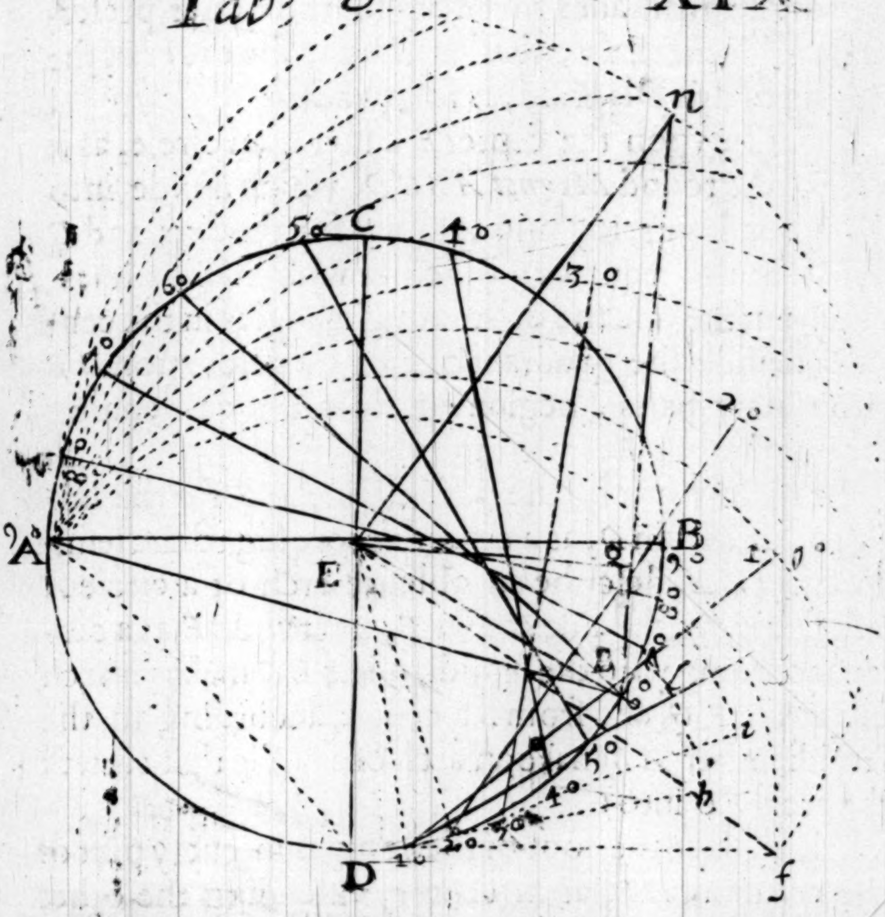
Eleuat. poli	Inclinat ad horiz.		Eleuat. pol.	Inclinat ad horiz.		Eleuat. poli	Inclinat ad horiz.	
	G.	M		G	M		G.	M.
1	2	2	31	51	49	61	74	58
2	4	4	32	52	54	62	75	33
3	6	6	33	53	56	63	76	7
4	8	8	34	54	56	64	76	41
5	10	10	35	55	55	65	77	15
6	12	11	36	56	52	66	77	49
7	14	13	37	57	48	67	78	25
8	16	13	38	58	42	68	78	55
9	18	12	39	59	35	69	79	27
10	20	10	40	60	26	70	80	0
11	22	5	41	61	17	71	80	32
12	23	59	42	62	6	72	81	4
13	25	50	43	62	54	73	81	35
14	27	39	44	63	40	74	82	7
15	29	25	45	64	26	75	82	38
16	31	9	46	65	11	76	83	9
17	32	50	47	65	55	77	83	39
18	34	28	48	66	38	78	84	10
19	36	4	49	67	20	79	84	40
20	37	37	50	68	2	80	85	10
21	39	7	51	68	43	81	85	40
22	40	34	52	69	23	82	86	10
23	41	59	53	70	2	83	86	39
24	43	21	54	70	41	84	87	9
25	44	40	55	71	19	85	87	38
26	45	58	56	71	57	86	88	7
27	47	12	57	72	34	87	88	35
28	48	24	58	73	11	88	89	4
29	45	35	59	73	47	89	89	32
30	50	43	60	74	22	90	90	0

CHAP. XXXVII.

Another Diagram of finding the angles of the Inclinatory-needle in any Paralell.

HEre we ſhall ſet downe another Diagram which doth properly ſhew the motion, conuerſion, and application which the needle maketh when that he is caried about the meridian of the *Terrella* or *Semiterrella* when the poles of the ſame lye in the horizon, in which circumparragation this needle deſcribeth two whole circles, as he paſſeth round about the meridian, as is demonſtrated in the twelfth chapter before, from the ſtone it ſelfe. For this needle being placed at the æquator, it ſeateth it ſelfe paralell to the *axis* of the *Magnet*, being caried further on the quadrant toward the pole, about 17 degrees it pointeth to the pole of his orbe, and neere about 33 and 34 minutes, hauing made a quadrant in his motion, he placeth himſelfe paralell to the æquator, and at right angles to the *axis* of the *Magnet*, and paſſing on to 45 degrees, this needle beholdeth there the æquator of his orbe, and comming to 90 degrees againſt the pole, it maketh one *axis* with the *axis* of the *Magnet*, and deſcribeth another quadrant, ſo that from the æquator to the pole in paſſing along this one quadrant of the ſtone, this needle hath made halfe a circle, ſo that if he ſhould make a perrambulation round about the whole

Tab: 8 XIX



whole meridian, he would make two epicicles, like to the motions aſcribed to ſome of the Planets.

But to make vſe of this motion for the inclination, we ſhall onely ſet downe what aſpects or angles the needle maketh with the *axis* of the earth at euery tenth degree from the æquator to the pole, where in this Diagram there be lines to the inſide of the quadrant *D B* for the inclination of the needle, which may alſo be produced outward into the orbe of *Magneticall* vertue vpon the limbe, as it is ſet out in the twelfth chapter, *Tab.IIII.Fig*.2. both in pricked lines, and alſo in the erection of a ſhort wier at euery tenth degree of the quadrant: therefore for the better preſeruing of this matter, we ſhall ſet downe the order of the making of this Diagram, as followeth.

Deſcribe vpon the center *E* a meridian circle, as it were of the round *Magnet A B C D*, which diuide into foure quadrants, ioyning *A* and *B* for the *axis*, and *C* and *D* for the æquator, together with ſtraight lines, which cut the one the other at right angles in the center *E*, deuide the quadrant of the poles eleuation *D B* into ninety parts, beginning from *D*, and ending the numbers in *B*, with the vſuall figures.

At *D* draw an obſcure paralell line *D F* for the horizon, and from *D*, as a center according to the ſemidiamiter *D A*, deſcribe an obſcure arch of a circle *A B F*, deuiding the line *D F* in *F*, next vpon *E*, as a center according vnto the ſemidiamiter *E F* make an arch of a circle *F G*, and from *B* a center, according to the ſemidiamiter *A B* make an arch of a circle that cutteth the arch *F G* into *G*.

Then place the foot of the compas in euery part of the quadrant *D B*, as in center, extending the other foot to *A*, and deſcribe arches to *F G*, and firſt place the foote of the compaſſe in the deuiſion of 10 in the quadrant, and opening the compaſſe to *A*, deſcribe the arch of a circle from *A* to the arch *F G*, and deuide this arch from *H* into ninety parts, firſt into 3 parts, then part euery one of theſe into 3 parts, containing ten parts apeece, if they were ſub-diuided into them, then from 10 in the quadrant, to 10 in the arch from *F G* draw a ſtraight line 10 and 10 for the line of the inclination, now draw an obſcure line from *E* to the de-

degree of 10 in the quadrant, and from this line at 10 make an obſcure line at right angles for the horizon to *E* to, then take the ſemidiamiter *D E*, and place one foote in this line from 10 to *H*, and from 10 as a center deſcribe an obſcure arch *H L* to the line 10 and 10, and this arch ſhall be the angle that the *Inclinatory-needle* maketh with the horizon, where the pole is eleuated ten degrees aboue the horizon, and the angle 10 *E* and 10 is the complement of the former angle.

Next place the foote of the compaſſe in the twentieth degree of the quadrant, and ſtretching it to *A* deſcribe the arch of a circle from *A* to the arch *F G*, which being diuided into ninty parts, firſt into three parts, and theſe into three parts, againe draw a line from 20 in the quadrant to 20 from the arch *F G*, now make an obſcure line from *E* to the 20 degree in the quadrant, and from this line at 20 make an obſcure line for the horizon at right angles to *E*, 20, take the diſtance from *E* 20, and place it in the line 20 *I*, and from 20 as a center, the compaſſes being vnremoued, deſcribe the arch *I M*, cutting the line 20 and 20 into *M*, which is the angle the *Inclinatory-needle* maketh with the horizon, and being ſet in the arch *D B*, the number of the degrees of this arch of inclination will appeare.

According to this order draw arches from *A* to *F G*, making the diuiſions in the quadrant the centers, and their diſtance from *A* the ſemidiamiters of them, diuiding theſe arches as afore is done, and drawing right lines to the correſpondent diuiſions in their ſeuerall arches from the ſeuerall degrees in the quadrant, whoſe reſpondent angles of inclination is knowne by making at the ſame and deſcribing arches accor-

ing

ding to their ſemidiamiter from *E*, as hath bene declared in the two former examples, which being reduced into degrees, by placing the arch in the quadrant *D B*, from *D* towards *B*, will ſhew the quantity of the needles inclination vnto the horizon and his angle with the ſame.

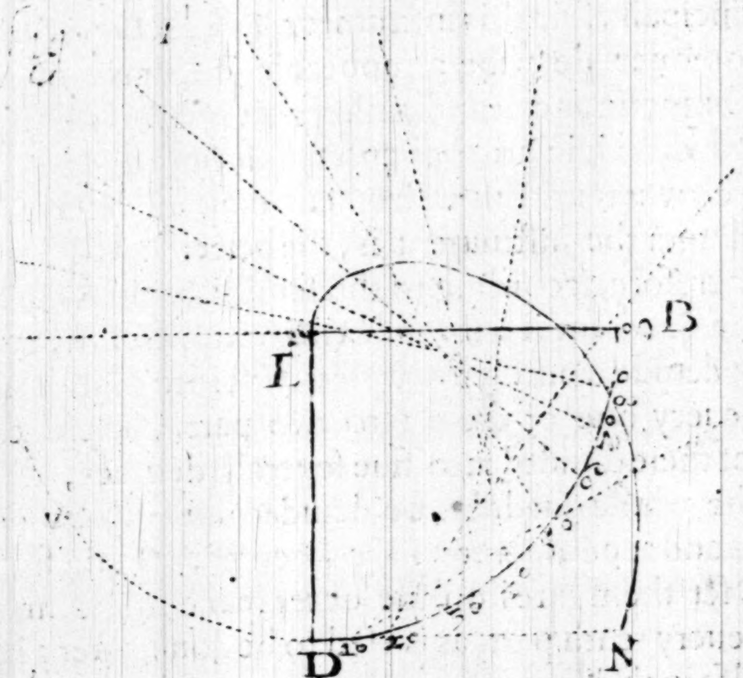
CHAP. XXXVIII.

Of finding by the Needles inclination vnto the horizon, the altitude of the Pole by an inſtrument.

FOr the performance hereof, it is neceſſary to haue the ſtraight lines of the needles inclination or aſpect to the *axis*, drawne in the former chapter obſcurely, deſcribed againe by the former art, and the quadrant *D B* diuided into his parts. At *D* draw a paralell line to *A B*, and take the ſemidiamiter *E D* and place it in this line to *N*, then ſet one foote of the compaſſe vnremoued on the 10 degree of the quadrant *D B*, and the other foote in the ſtraight line of ten obſcurely drawne, making a note there, then remoue the compaſſe, retaining the ſemidiamiter *E D*, and place one foote in 20 in the quadrant, and the other in the line of 20, making another note or pricke there, ſo place this ſemidiamiter of *E D* from 30, 40, and the reſt in the quadrant on their proper lines, making notes and prickes vpon them where they end,

now

Tab XX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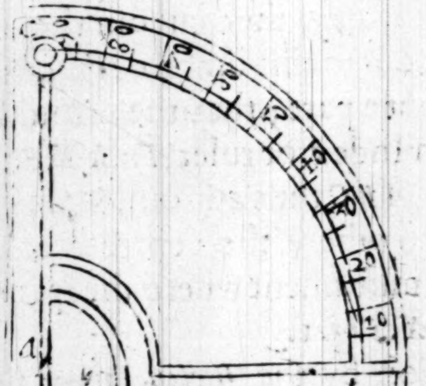
A
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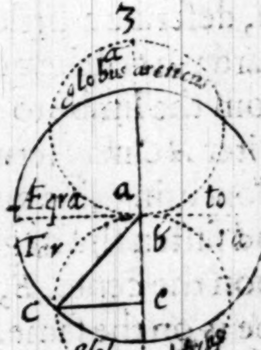
3
a
globus arcticus
Eqra
a
to
Ter
b
ra
C
c
globus antarctus

T

now ioyne theſe notes and prickes together with conuenient lines, and there will be a ſpirall line deſcribed of principall vſe in this inſtrument, *Tab.* 20. *Fig.* 1.

Moreouer deſcribe a moueable quadrant of the ſame bigneſſe and ſemidiamiter that *E D B* is of, to be moued vpon it in a paper apart, paſt-boord, or ſome mettall, whereon this inſtrument may be deſcribed, (the larger the inſtrument is, the better it will be for vſe) therefore, according to the ſemidiamiter *E D*, deſcribe a quadrant *A B C Tab.XX.Fig.*2. from *A* the center, & deuide it into ninety parts, firſt into nine parts, then euery one of theſe into two parts, and euery one of theſe diuided into fiue ſeuerall degrees, thus will the whole quadrant be deuided into ninety degrees; and at 90 degrees make a center at *C*, and from *B* to *C* ſet the figures on the outer ſpace in the limbe vnto euery tenth part, as is vſed to be done, after a little halfe inch diſtance; from the center of the quadrant *A*, deſcribe a little limbe or ſtay, then cut out the inward part of the quadrant *C B* to this limbe or ſtay, and from the limbe to *A* cut out a part, that the ſemidiamiter *A C* may ſerue for an Index or ruler, *Ta.XX.F.*2. Now bring this quadrant *A B C* thus cut out, & place, and faſten the degree of 90 where the center is at *C*, vpon the center *E*, on the inſtrument where the ſpirall line is on the ſame, *Tab.XX.Fig.*1.

In the time of obſeruation by the *Inclinatory-ring*, before deſcribed, marke what degree in the ring the *Inclinatory-needle* pointeth at in the meridian circle of the ſame, then in this inſtrument here deſcribed, note the degree obſerued in the ring vpon the moueable quadrant from *B* to *C*, and turne this quadrant about till that this note or degree doth touch the ſpirall line;

here ſtay the moueable quadrant, & his index *C A* will ſhew in the quadrant *D B*, the altitude of the pole in that place.

So back-wayes ſet the index of the moueable quadrant to any eleuation of the pole, and where the ſpirall line cutteth the limbe of the moueable quadrant, the degrees and parts ſhew what ſhould be the number, due to the angle of the *Inclinatory-needle*, and what parts he would point out in that place. A Table of the inclination of the needle, anſwering to euery eleuation of the pole, might be made by this inſtrument.

CHAP. XXXIX.

Of finding the needles inclination in euery latitude by Table.

THe way to find the angle, which the *Inclinatory-needle* maketh with the horizon in any latitude, or the degrees correſpondent, by a table, is moſt profitable and ready, becauſe that knowing any one of theſe two, that is, either the altitude of the pole, or the angle of inclination to the horizon, the other is preſently knowne by the table.

Seeke in this Table following the altitude of the pole in the left collumne, and in the next place towards the right hand you ſhall find the degrees and minutes of the needles inclination, vnto the horizon, anſwerable for that latitude; as for example. I would know what would be the arch of the angle of the *Inclinatory-needle* where the pole is eleuated 60 degrees, I ding to their ſemidiamiter from *E*, as hath bene declared in the two former examples, which being reduced into degrees, by placing the arch in the quadrant *D B*, from *D* towards *B*, will ſhew the quantity of the needles inclination vnto the horizon and his angle with the ſame.

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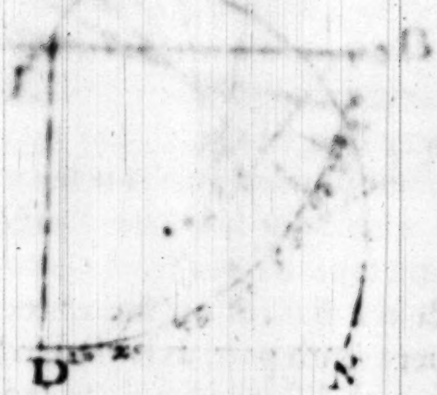
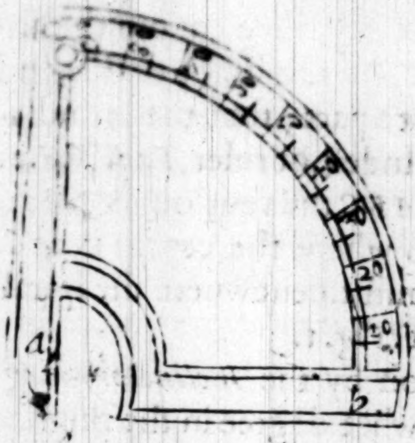
Ch. XX


D
D
N


20
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a
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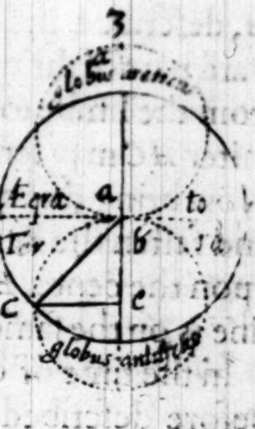
3
globus arcticus
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c
e
globus antarticus

now ioyne theſe notes and prickes together with conuenient lines, and there will be a ſpirall line deſcribed of principall vſe in this inſtrument, *Tab.* 20. *Fig.* 1.

Moreouer deſcribe a moueable quadrant of the ſame bigneſſe and ſemidiamiter that *E D B* is of, to be moued vpon it in a paper apart, paſt-boord, or ſome mettall, whereon this inſtrument may be deſcribed, (the larger the inſtrument is, the better it will be for vſe) therefore, according to the ſemidiamiter *E D*, deſcribe a quadrant *A B C Tab.XX.Fig.* 2. from *A* the center, & deuide it into ninety parts, firſt into nine parts, then euery one of theſe into two parts, and euery one of theſe diuided into fiue ſeuerall degrees, thus will the whole quadrant be deuided into ninety degrees; and at 90 degrees make a center at *C*, and from *B* to *C* ſet the figures on the outer ſpace in the limbe vnto euery tenth part, as is vſed to be done, after a little halfe inch diſtance; from the center of the quadrant *A*, deſcribe a little limbe or ſtay, then cut out the inward part of the quadrant *C B* to this limbe or ſtay, and from the limbe to *A* cut out a part, that the ſemidiamiter *A C* may ſerue for an Index or ruler, *Ta.X X.F.* 2. Now bring this quadrant *A B C* thus cut out, & place, and faſten the degree of 90 where the center is at *C*, vpon the center *E*, on the inſtrument where the ſpirall line is on the ſame, *Tab.X X.Fig.* 1.

In the time of obſeruation by the *Inclinatory-ring*, before deſcribed, marke what degree in the ring the *Inclinatory-needle* pointeth at in the meridian circle of the ſame, then in this inſtrument here deſcribed, note the degree obſerued in the ring vpon the moueable quadrant from *B* to *C*, and turne this quadrant about till that this note or degree doth touch the ſpirall line;

here ſtay the moueable quadrant, & his index *C A* will ſhew in the quadrant *D B,* the altitude of the pole in that place.

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CHAP. XXXIX.

Of finding the needles inclination in euery latitude by Table.

The way to find the angle, which the *Inclinatory-needle* maketh with the horizon in any latitude, or the degrees correſpondent, by a table, is moſt profitable and ready, becauſe that knowing any one of theſe two, that is, either the altitude of the pole, or the angle of inclination to the horizon, the other is preſently knowne by the table.

Seeke in this Table following the altitude of the pole in the left collumne, and in the next place towards the right hand you ſhall find the degrees and minutes of the needles inclination, vnto the horizon, anſwerable for that latitude; as for example. I would know what would be the arch of the angle of the *Inclinatory-needle* where the pole is eleuated 60 degrees, I

TABLE.

Eleuat. poli	Inclinatio ad horizontem.	′	″
1	2	11	15
2	4	10	13
3	6	26	55
4	8	31	23
5	10	33	41
6	12	33	50
7	14	31	53
8	16	27	52
9	18	21	50
10	20	13	47
11	22	3	45
12	23	51	46
13	25	37	52
14	27	22	4
15	29	4	23
16	30	44	53
17	32	23	34
18	34	0	27
19	35	35	35
20	37	9	0
21	38	40	42
22	40	10	41
23	41	38	58
24	43	5	37
25	44	30	26
26	45	53	43
27	47	15	25
28	48	35	33
29	49	54	8
30	51	11	9
31	52	26	38
32	53	46	55
33	54	53	1
34	56	3	56
35	57	13	21
36	58	21	19
37	59	27	50
38	60	32	59
39	61	36	46
40	62	39	0
41	63	39	56
42	64	39	29
43	65	37	41
44	66	34	31
45	67	30	0
46	68	24	10
47	69	17	2
48	70	8	38
49	70	58	59
50	71	48	7
51	72	36	0
52	73	22	38
53	74	8	2
54	74	52	11
55	75	35	6
56	76	16	51
57	76	57	28
58	77	36	59
59	78	15	23
60	78	52	41
61	79	28	51
62	80	3	56
63	80	37	54
64	81	10	47
65	81	42	36
66	82	13	23
67	82	43	9
68	83	11	56
69	83	39	45
70	84	6	37
71	84	32	30
72	84	57	24
73	85	21	22
74	85	44	24
75	86	6	31
76	86	27	44
77	86	48	5
78	87	7	36
79	87	26	18
80	87	44	9
81	88	1	10
82	88	17	23
83	88	32	49
84	88	47	29
85	89	1	22
86	89	14	30
87	89	26	54
88	89	38	37
89	89	49	39
90	90	0	0

ſeeke this 60 degrees in the left columne of the table, and there I find anſwering thereto 78 deg. 52′, and 41″, the arch that the *Inclinatory-needle* maketh with the horizon, where the pole is eleuated 60 degrees.

The manner to calculate this table by the doctrine of triangles, is to obſerue the proportion that is vſed in making the Diagram ſet downe. *Tab.XIX.Fi.*1. as let our example of 60 degrees for the altitude of the pole be numbred in the quadrant *DB* in the XIX. Table from *D* to *R* the arch *ADR* being 150 degrees, the angle *ERA* will be 30 degrees. The ſemidiamiter *ER* being 10000 *RN* equall to *AR*, the cord ſubtending the arch *ADR* will be 19318, and *EN* equall to *EF* 17305, being the ſecant of the angle *DEF*, whoſe tangent *DF* 14142 is equall to the cord *AD*, ſubtending 90 degrees, theſe three ſides of this triangle *ER*, *RN*, *EN*, being giuen, the angle *ERN* is thus knowne.

As the baſe thereof *RN* 19318 is vnto the ſumme of the ſides *RE* and *EN* being 27305, ſo *NO* the ſegment of the ſide 7305 is vnto *NP* the ſegment of the baſe 10325, which being taken from *RN* 19318, the remainder *PR* 8993, whoſe halfe *RQ* 4496 $\frac{1}{2}$ is the ſinus of the angle *REQ*, conſiſting of 26 deg. and 43′ whoſe complement being 63 deg. and 17′, is the angle *ERN*, which we deſire to know.

Ioyne this angle *ERN*, being 60 deg. 17′ vnto the angle *ERA*, being 15 degrees, both which make the whole angle *ARN* to conſiſt of 78 deg. and 17′ contained within his arch *ASN*.

Becauſe that the angle *RED* conſiſteth of 60 deg. therefore for anſwerable hereunto, take 60 degrees of this arch *NSA* deuided into 90 degrees, which ioyned to *R* make the angle *S R N* to conſiſt of 52 degrees and 12′, which being ſubducted from the angle of *E R N*, containing 63 deg. and 17′, the angle *S R E* will retaine onely 11 degrees and 5′, whoſe complement *S R T* conſiſteth of 78 deg. and 55′, declaring the inclination of the *Magneticall* needle vnto the horizon *R T*, where the latitude of the place is 60 degrees.

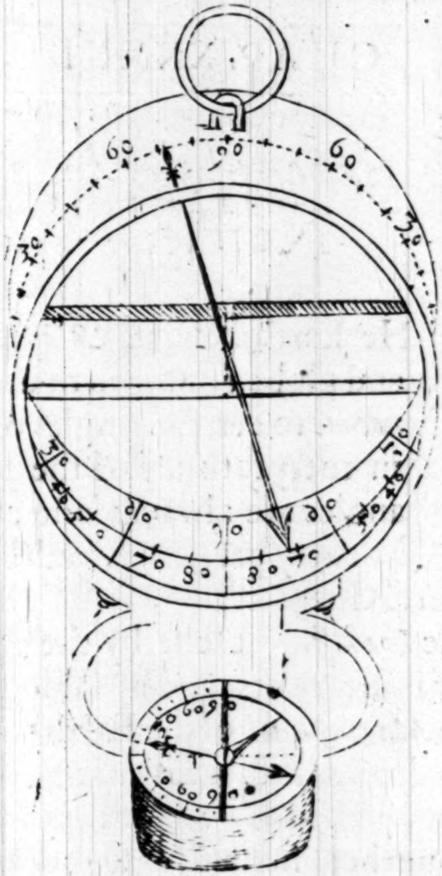
CHAP. XXXX.

Of finding the angle of Inclination, the Magneticall meridian, and the Azimuth together.

IT is very conuenient at ſea to haue a large *Inclinatory-ring* with his *Magneticall needle* of a foote diamiter, that the diuiſions of the meridian circle being large; the degree of the mouing needle will the better be perceiued, and to haue a waight of diuerſe pounds faſtned at the bottome to hold this ring plumbe and ſteady: moreouer on this waight I would haue a compaſſe, or directory-needle placed in his bottome, and a beame for a diamiter and ſemidiamiter of braſſe, before deſcribed, for the obſeruing of the *Magneticall* azimuth, as was appointed in finding the variation of the Compaſſe.

Theſe two *Magneticall* needles, the one in the *Inclinatory-ring*, the other in the cauitie of the bottome, being placed fiue or ſixe inches aſunder, will not hin-

der



der or attract the one the other, being out of the vigor in this diſtance of their *Magneticall* orbes.

A long wier that hath bene excited *Magnetically*, being thruſt through a corke, and placed in the water, will ſhew the Inclination and *Magneticall* meridian, at one inſtant, in his quiet ſituation.

CHAP.

CHAP. XXXXI.

Of the variation of the Inclinatory- Needle.

THe Earth being a *Magneticall* body and globe, conformeth the *Inclinatory-needle* to certaine angles of inclination in euery latitude of the pole, which angles are alwayes one and the ſame in euery paralell, as hath bene demonſtrated in diuerſe Chapters.

Both by the *Load-ſtone* it ſelfe, by the fundamentall hypotheſis, by inſtruments, and by tables; but becauſe that the globe *Magneticall* of the Earth hath many cauities filled with other ſubſtances different from *Magneticall* nature, and many mountaines *Magneticall* mounted aboue theſe ſubſtances higher and lower, ſo that ſome attract, being aboue the point of the *Inclinatory-needle*, ſome being vnder it; ſome placed before it, draw the point of the *Inclinatory-needle* vp vnto them, other behind it, beeing alſo adamantiue ſorts will haue this *Inclinatory-needle* ſtrike ſaile to them alſo, by which meanes the naturall conformity of the *Inclinatory-needle* to his naturall angles is much diſturbed and deprauedd, whereby it commeth to paſſe that this needle hath his variation alſo, as well as the directory needle hath, as is before demonſtrated.

Therefore the variation of the *Inclinatory-needle* is, when in one altitude of the pole this needle pointeth out another angle, different from the true and reſpondent angle of that latitude of the pole, being hindred by a mountaine, or part *Magneticall*, that doth attract one of the points of the *Inclinatory-needle*, approching neere vnto it, either neere the poles or æquator, in ſo much that the angle of inclination is made leſſe or more then it naturally would be.

In ſailing Eaſt or Weſt vpon a paralell, hauing hie land on the ſide towards the pole, conſiſting of *Magneticall* ſubſtance, this will attract the *Inclinatory-needle*, and cauſe his naturall poſition to be more perpendicular then it would be.

If the ſhore about the pole be ſituated betweene the *Inclinatory-needle* and the æquator, this adamantine eminency will attract the needle vnto it, making his inclination leſſe plumbe then naturally it is.

In ſailing Eaſt or Weſt neerer the æquinoctiall, where the cariage of the *Inclinatory-needle* is leſſe perpendicular, and more tending to the leuell with the horizon, the *Magneticall* eminency betweene the pole and the needle, will pull downe the higher end of the ſame, and make him more paralell to the *axis* of the earth, then naturally he could endure.

Euen ſo an adamantine mountaine, betweene the *Inclinatory-needle* and the æquinoctiall line, will lift vp the lower end of this needle, being within the *Magneticall* vigor of that mountaine, and make him more paralell with the horizon then his naturall conformity requireth in that paralell.

The variation of the *Inclinatory-needle* is greater in the parts neerer the æquinoctiall, then it is in the parts neere the poles, where this needle is not attracted ſo many degrees from his naturall angle, as vſually he is neere the æquinoctiall.

If in the parts neere the poles, the *Inclinatory-needle* be caried betweene two eminences *Magneticall*, in that ſpace of the ſtraight where both their vigors be of like validity, they will make the application of this needle perpendicular, croſſing them both at all right angles, not much vnlike, as it is in XV. Chapter of applications, *Table VIII. Fig.* 1.

In ſailing neerer the æquinoctiall in ſtraights betweene two adamantine mountaines, whoſe vigour attractiue ſurpaſſe the generall vertue diſponent of the *Magneticall* globe of the earth, theſe will lay the *Inclinatory-needle* in a paralell and leuell to the horizon, though they be many degrees from the æquinoctiall, as Chapter XV. *Tab. VIII. Fig.* 2.

Laſtly, in paſſing or ſailing neere and ouer a vigorous *Magneticall* rocke, in the ſea, or earth, vnder vs, in approching neerer vnto it, the ſame will attract the *Inclinatory-needle* from his right place, and comming neerer the rocke, it will alter him much more, and paſſing ouer the ſame, it will attract the needle perpendicularly, and being paſt, this needle will be freed by little and little from that diſturbance of his naturall inclination.

Theſe varieties are found vpon the *Magneticall* globe or *Terrella*, by hauing a conuenient peece, or peeces of iron placed thereon, as hath bene ſayd, and placing the *Inclinatory-needles*, before deſcribed in the II. chapter, the one of them put vpon a Lute-ſtring, the other in his frame, *Tab. II. Fig.* 17. 18 or 19. ſo that I hope I need not ſet downe any types hereof, for the ingenious will better conceiue how to gather this matter from the globe of the *Loadſtone*, then I can poſſibly explaine in many troubleſome figures, or the workeman deliniat by his skill vnto you in printed tables and figures.

CHAP. XXXXII.

Of finding the variation of the Inclinatory-needle.

HAuing declared the manifold cauſes of the variation of the *Inclinatory-needle* from his true and naturall angle of inclination with the horizon; it followeth that we deliuer plainely how to diſcerne theſe euents when they ſhall fall out, which are known perfectly by hauing the true eleuation of the pole, where theſe matters ſhall be required.

The rules and wayes how to know the eleuation of the pole in all places, is ſo perfectly ſet out by moſt Aſtronomers and writers of Nauigation, and ſo well knowne to all expert Pilots, that it is a thing needleſſe here to repeate them.

Beſides the ingenious Pilot knowing the eleuation of the pole in ſome places of his voyage that he hath paſſed, by keeping a true, not a dead reckoning of his courſe in pricking his Card aright, and obſeruing the way with the logge-line, with other currants and occurrants, will giue a very artificiall coniecture of the eleuation of the pole in that place where he is, though he ſee neither Sunne nor Starres.

Notwithſtanding becauſe the skilfull Pilots may be hindred in this kind of obſeruation, by the falling of the ſhip to Lee-wards, and by other extraordinary change of weather, and other diſturbances that may many wayes fall out at ſea, therefore I will onely remember one way out of the principals before deliuered, whereby he may at any time of the day, the Sunne ſhining, know the altitude of the pole.

This thing is chiefly performed by knowing the true variation of the Compaſſe, which ſheweth the true meridian for that place, preſently ſeeke out the true Azimuth alſo, which is perfectly knowne by the ſhadow of the Sunne vpon the limbe of the Compaſſe, by the furniture of the beame, before deſcribed, inſtantly take the altitude of the Sunne by the *Iacobs* ſtaffe at ſea, or a large quadrant at land.

The true Azimuth and Almicanter thus knowne, ſeeke the point where they croſſe the one the other in the Rete of the *Mathematicall Iewell* and *Aſtrolabium Catholicum*, then obſeruing the paralell of the Sunnes declination for that day, turne about the Rete of this inſtrument, vntill this paralell of the Sunnes declination be touched by the point, where theſe two circles of altitude and poſition meete, and then the horizon of the Rete will ſhew in the limbe the latitude of that place.

The latitude of the pole for any place being knowne, the true angle of the *Inclinatory-needle* is manifeſt and apparant, as it is ſet downe and knowne by the XIII. chapter, in the chapter to know the angles of inclination by the inſtrument, and in the table of the degrees of the *Inclinatory-needle*, anſwerable to euery eleuation of the pole.

Now obſerue the degrees that the *Inclinatory-needle* pointeth out in his ring in that place, and take the difference of theſe from the degrees of the true angle, and that is the variation of the *Inclinatory-needle* for that place.

CHAP. XXXXIII.

Of finding the Longitude.

HEre I purpoſed to haue ended this ſhort Treatiſe of *Magneticall* matters, but becauſe that this thing is not altogether impertinent thereunto, I thought it not ſuperfluous to annex this little chapter of finding the longitude, for although that the *Magneticall* needles, before treated of, do not ſhew the longitude; yet becauſe the true meridian and altitude of the pole is knowne by them, there is much helpe brought thereby for the knowledge of the longitude, which by a few eaſie obſeruations more, from the body of the Moone, will be obtained, whoſe motion if it ſhould be ſet downe and ordered in an exact manner, would require a large diſcourſe, with many rules and obſeruations of the Moones inequality of motion, anomaly and proſtapheriſis, of his excentricity, paralaxis, with the varietie of his latitude and nodes, which thing, being very laborious and curious, ſhall be here omitted, referring you herein to *Tycho Brahe* and his rules, and onely I ſhall here ſet downe rules to know the place of the Moone at a larger ſcantling, yet very neere the truth

(though

(though not the truth it ſelfe, which peraduenture the beſt Studied in this kind can very hardly do) only borrowing halfe a dayes motion at the Moone, wherein the matters before mentioned will not alter many minutes.

Prouide an Almanake or Ephemerides for any place or port, wherein the apparent place of the Moone in the Zodiacke is exactly ſet downe in degrees and minutes for the noone of euery day, eſpecially of the day of obſeruing, then take the difference of the Moones motion from the day before, and reduce it into minutes, deuiding them by 24 houres, the quotient will ſhew what minutes the Moone moueth in an howre.

Now take the altitude of the Moone at any time of the day or night by the *Iacobs* ſtaffe, or a quadrant, then obſerue the Azimuth of the Moone by ſhadow, (as before for the Sunne) or by a ruler with ſights, which if it do differ any howers from the meridian, alow the parts due of the Moones motion.

Then ſeeke in the Rete of the *Mathematicall Iewell*, or *Vniuerſall Aſtrolabe*, where the Azimuth and Almicantaraph of the Moone, newly obſerued, cut each other, ſetting the horizon to the altitude of the pole, and looke what paralell doth cut theſe two, and follow the ſame vnto the Eclipticke line (or do the like of the Moones latitude) in that ſigne, degree, and minute of the Zodiacke, the Moone is in at that inſtant.

Theſe degrees, fewer or more then thoſe of the radicall and fixt meridian, for which the Ephimerides was made, do ſhew what howres and parts are to be added, if the obſeruation be towards the Weſt, or ſubſtracted if in the Eaſt, to this meridian (it is to be noted that euery hower cōtaineth 15 degrees of the Equinoctiall) and thus the longitude of that place you are in, will be attained, which you deſire.

But to find the longitude of any place you go to, from the place you paſſe from, by theſe *Magneticall-needles* onely, it will be neceſſary to pricke your Card as well by the degrees of latitude of the pole, correſpondent to the angles of the *Inclinatory-needle*, as by the way the ſhip maketh vpon the points of the *Directory-compaſſe*, and therefore it will be fit to haue both theſe needles placed together, as in the type of the XL. Chapter, and pendant before the Mariner at the helme with the Compaſſe and Trauerſ-boords for them both.

Now for this purpoſe I would haue another Trauers ruler or limbe for the quadrant of the *Inclinatory-ring*, placed before him, as it is deſcribed in the Page following, where there is only 30 degrees deuided vpon the ſame, which being twice more repeated, will make vp 90 degrees, euery degree hath 6 holes, for pegs to be put into them, for the number of 10 minutes apeece, and on the firſt columne on the left hand there are 4 holes made to receiue pegges according to the number of howers you ſaile on ſuch a degree and minute, pointed in the *Inclinatory-ring*.

Beſides theſe inſtruments, prouide a perfect Sea-card for your voiage, with the lines of the winds, & the lines of the longitude & latitude placed therein, then obſeruing the way that the ſhip maketh in an hower, by the log-line prick your way on the card out of the Trauerſ-boord for the point of the Compaſſe you ſaile on, alſo by this ſecond worke pricke your Card by the ſame way with the degree of latitude you finde by the degree of the *Inclinatory-angle* in the Trauerſ-limbe, as it

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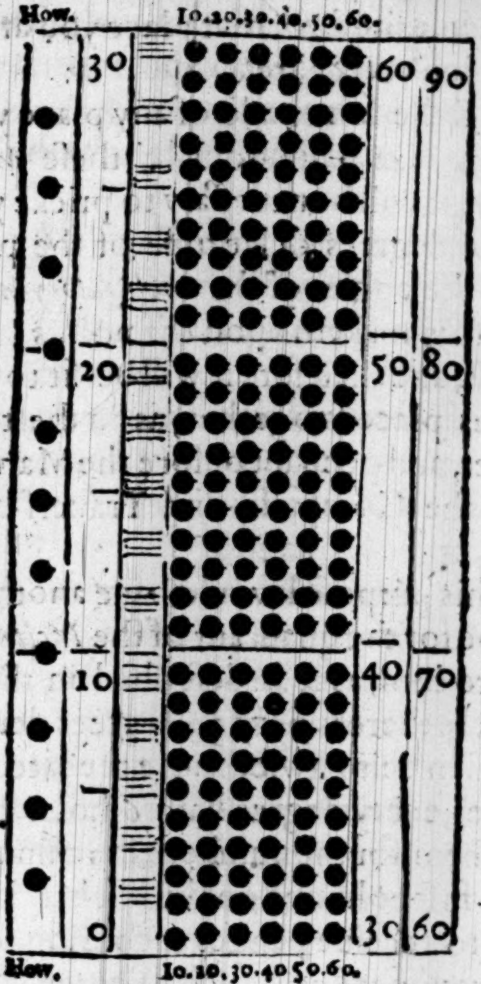

is correſpondent by the wayes, inſtruments, and precepts deliuered from the *Inclinatory-needle*, then obſerue in the meeting of theſe two ſorts of pricking, what meridian paſſeth by them in your Card, and that ſheweth the longitude of the place where you are, from that from whence you came; and thus your Card is pricked both for longitude and latitude only by theſe *Magneticall* needles, when you can ſee neither Moone nor Starres.

If any errors ſhould chance to fall out by any variations of either needle, then at any time when the Sun doth ſhine they may be amended by the precepts already largely deliuered in that caſe of either, both in many Chapters of this booke, and in the laſt precedent Chapter.

CHAP. XXXXIIII.

Of the matter of the Magneticall globe of the earth by the Needle.

AT length, we haue brought our ſhort Treatiſe *Magneticall* principally & moſt profitably to declare the nature of the *Directory* and *Inclinatory-needle*, both towards the *Terrella* and *Semiterrella*; and towards the *Magneticall* globe of the earth, and how the proportions and ſimilitude of their applications and conformities to both are alike and the ſame.

Onely the *Magneticall-needle* being of a fæminine and ſequent ſubſtance, as hath bene demonſtrated in the VIII. XXI. and XXII. Chapters, doth behold the round *Magnet*, and the round Iron, with that point that is of the ſame nature and demonſtration that the pole is, which he followeth and affecteth, contrary to the nature *Magneticall*, that is in the Adamants themſelues, one towards the other, or of the needles one towards the other.

But this *Magneticall-needle* being freed from the *Magneticall* orbe of the *Loadſtone* and Iron, will haue that point of the needle that followed them directed by the vertue *Magneticall* of the earth into a contrary prouince of polar preheminence.

For the *Magneticall-needle* doth conforme it ſelfe vnto the Earth in the ſame faſhion that the Adamant and *Loadſtone* it ſelfe doth; neither is it ſo ſeruiceable vnto the *Magneticall* globe of the earth as he is vnto the *Magnet* and Iron, but is of a fellow-like ſpecies with the earth, as well as the Adamants themſelues are.

Whereby I do gather that the matter of the interior parts of the *Magneticall* globe of the earth is not the ſame with theſe we know of the *Loadſtone* and iron, into whoſe bowels neuer any mã, by the deepeſt mines, or other paſſages of fiſſurs and cauities, made by great Earth-quakes, euer yet deſcended to ſhew vnto vs any part of the earths interior ſubſtance *Magneticall*, and though I take the matter of the bowels of the earth to be *Magnetical*, yet the application of this *Magneticall-needle* demonſtrateth, that the *Magnetical* globe of the earths inward ſubſtance cõſiſteth neither of ſollid *Loadſtone*, nor of iron-like mine or clay or ſuch like materials, as they which haue thought themſelues moſt skilfull in *Magneticall* Philoſophy haue imagined.

For if the *Magneticall* globe of the earth were of any Iron-like ſubſtance, then that point of the needle that affecteth a polar iuriſdiction, placed neere the *Loadſtone* and the iron, would alſo, being applied vnto the earth, behold the ſame prouince and iuriſdiction polar, being directed by the vigor of the earths *Magneticall* orbe of like nature; but this is not ſo, as all confeſſe and may proue.

Therfore I hold that the great *Magnetical* globe of the earth conſiſteth of a *Magneticall* ſubſtance vnknowne vnto vs, as alſo the bodies of the *Magneticall* globe of the Moone and of the reſt do; and ſo conclude that the workes of God are moſt wonderfull, and altogether paſt finding out.

But here before I end, I am to ſatisfie that I made promiſe of in the XII. Chapter, that I would ſhew my conceipt of the reaſon why the needle in his paſſage from the æquator of the *Magnet* by the pole, to the æquator againe, ſhould make the circumuolution of an whole circle in turning about his foote, hauing paſſed a ſemicircle of the *Terrella* or *Semiterrella*, and would make another whole circle about the other ſemicircle of contrary nature with his other point.

For to cleere this with the nature of the two prouinces, which is aduerſe one vnto the other. I would wiſh that you would conceiue and propound two globes of *Magneticall* nature and ſubſtance, as tender as clay, the one of them to be animated with the North and articke vertue at both poles, as *Tab.XX. Fig.3. a a*, to turne to the North onely: and the other globe, with his poles *Tab.XX. Fig.3. b b* to be endowed with the antarticke power to moue to the South onely.

Now if the globe of the earth, or of the *Magnet*-ſtone were made onely of one of theſe globes, then there would be a ſtrife betweene the poles of one of the globes, which ſhould behold his peculiar point, as if the pole *a* of the North vertue ſhould behold the North; the other pole *a* of the ſame globe, being of articke nature, would alſo ſtriue to behold the North, or at leaſt in their equality of power would rather reſpect Eaſt and Weſt, ſo that there would be no ſtability by the poles of ſuch kind of globes.

Therefore the skilfull Potter, who made the earth and all *Magneticall* bodies at the creation, and gaue life and vigor to all things, thought fit to prouide two *Magneticall* globes, the one of poles and circumference of North and articke nature, *Tab. X X. a a*, and another globe of South and antarticke vigour, *Tab. X X. Fig. 3. b b*, that theſe vnited together, the one might keepe the other in ſteady poſition, yet becauſe that theſe globes touching the one the other but in a point at *a* and *b*, *Tab. X X. Fig. 3.* could not keepe any firme ſteadfaſtneſſe, therefore this skilfull Potter vſed the Art of Geometrie to put theſe two *Magneticall* globes, with all their efficacie, into one globe, as *Plato* doubled the Cube, and whereas the ſlope line *b c*, *Tab. X X. Fig. 3.* in the figure is double to the ſide-line *c e*, *Tab. X X. Fig. 3.* therefore he extended theſe two models of theſe two globes, like clay, extinguiſhing the poles that touched at *a* and *b*, *Tab. X X. Fig. 3.* and expanded the ſame vnto the æquator of a doubled globe, that contained within his diamiter both theſe globes of articke and antarticke nature, the one of them on the North-ſide of the æquator, and the other on the South-ſide of this large extent, with the efficacy of their materials *Magneticall* and circumference, wholly bending to their proper prouince and poles, and becauſe the efficacy of one of theſe prouinces from the æquator, is the effect and power of an whole globe of one ſimple nature *Magneticall*, therefore the *Magneticall-needle* paſſing this ſemicircle or hemiſphere, doth deſcribe a whole circle, with the diſtinction of his parts and quadrants by the point, that is of the ſame nature; as alſo paſſing about the other hemiſphere, the other point of the needle being of the nature of this ſide, doth trace another whole circle about

bout his foot; ſo that here is two whole circles pricked out by the needle in paſſing about the earth, or the rounded *Loadſtone*; And thus haue we briefly and plainly tricked out that which we had to ſay of *Magneticall Bodies and Motions.*

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